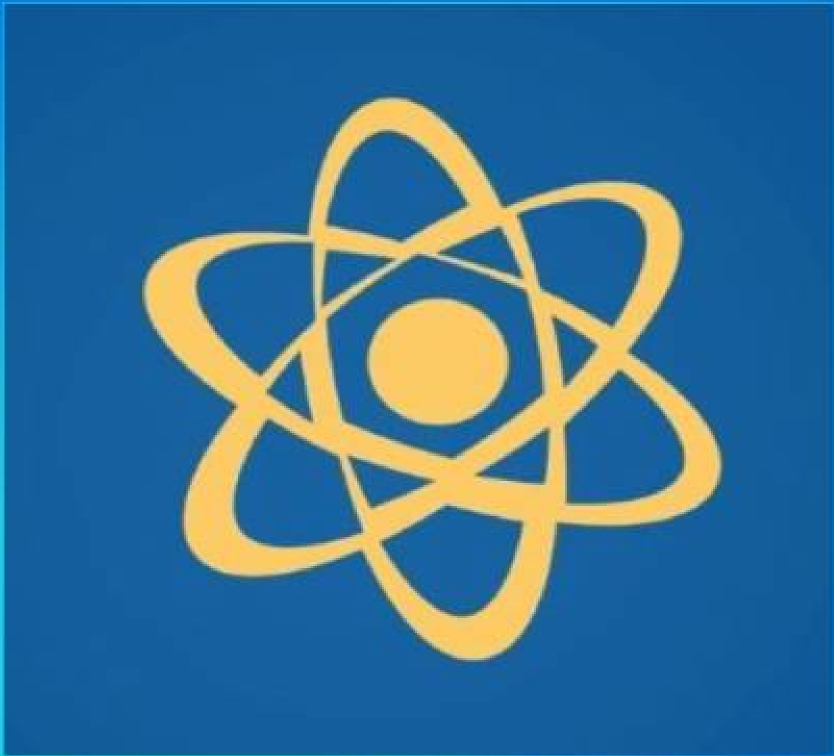
Board of Intermediate Education,
Andhra Pradesh

Intermediate



PHYSICS

Workbook

Second Year

English Medium

Prepared by group of Jr. Lecturers

Sri. V. Rama Krishna, I.R.S.
Secretary

PREFACE

"I hear and I forget – I see and I remember - I do and I understand – I think and I learn"

The Board of Intermediate Education, Andhra Pradesh, Vijayawada made an attempt to provide work books for the thirst time to the Intermediate students with relevant and authentic material with an aim to engage them in academic activity and to motivate them for self learning and self assessment. These work books are tailored based on the concepts of "learning by doing" and "activity oriented approach" to sharpen the students in four core skills of learning – Understanding, Interpretation, Analysis and Application

The endeavour is to provide ample scope to the students to understand the underlying concepts in each topic. The workbook enables the student to practice more and acquire the skills to apply the learned concept in any related context with critical and creative thinking. The inner motive is that the student should shift from the existing rote learning mechanism to the conceptual learning mechanism of the core concepts

I am sure that these compendia are perfect tools in the hands of the students to face not only the Intermediate Public Examinations but also the other competitive Examinations

My due appreciation to all the course writers who put in all their efforts in bringing out these work books in the desired modus.

--- V. Rama Krishna, I.R.S.
Secretary,
B.I.E., A.P., Vijayawada.

PHYSICS - WORKBOOK - II Year

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1 .WAVES

Key points to remember:

- The origin of waves in a medium is due to the disturbance created in that medium.
- Waves propagate and transport energy through the medium.
- When a wave is propagating through the medium, the particles of the medium get oscillated or vibrated.
- The particles just oscillates, they do not leave their original positions during the propagation of the waves
- Three types of waves: mechanical waves, electromagnetic waves and matter waves
- Mechanical waves: sound waves, water waves, waves in strings, earth waves, tidal waves etc
- Electromagnetic waves: light waves, radio waves, sun rays, etc
- Matter waves: waves associated with moving particles like protons, electrons, neutrons, etc

  (if the particle mass is considerably high, the wave characteristics predominated by the mass)
- To describe the propagating wave or progressive wave in a medium, a mathematical harmonic function is necessary that depends on both position (x) and time (t) as $y(x, t) = A \sin (kx-\omega t)$
- If the wave expression is written as $y(x, t) = A \sin (kx-\omega t+\phi)$ then we can have initial phase of the wave is ϕ
- The speed of a mechanical wave in a medium can be depended on inertial and elastic properties of that medium
- At a rigid boundary, the resultant displacement of an incident and reflected waves will be zero, that is $y = y_i+y_r = 0$
- Due to the overlapping of periodic incident and reflected waves, a standing waves pattern is formed. The amplitude of standing waves does not vary with time.
- In a travelling wave, both the position (x) and time (t) variables are involved within a harmonic function where as in a stationary wave, they gets separated by two harmonic functions
- The condition of external frequency is almost closed to the natural frequency of any medium then **Resonance phenomenon** occurs. In that condition the particles of the medium vibrates with maximum amplitude.
- Formation of beats will be depends on the interference of sound waves
- Beat frequency is equal to the difference of two sound waves individual frequencies
- Beats principle can be applicable in tuning the musical string instruments like guitar, violin, veena, sitar, etc.

- Doppler effect occur when there is relative motion between source and observer
- Doppler shift is equal to the difference of original frequency and apparent frequency
- The general equation for apparent frequency calculation heard by observer is

$$\nu^1 = \left(\frac{v \pm v_o \pm v_w}{v \pm v_s \pm v_w}\right) \nu$$

  Where ν and ν^1 be the original and apparent frequencies

  v, v_s,v_o and v_w be the velocities of sound wave, source, observer and wind (air) respectively.

  Sign convention:

  (i) If any velocity/velocities (v_s/v_o/ v_w) have same direction to the propagation of wave (v) then assign –ve sign to it.

  (ii) If any velocity/velocities (v_s/v_o/ v_w) have opposite direction to the propagation of wave (v) then assign +ve sign to it.
- There is a limitation for Doppler effect such that the speed of source/observer/wind should not be exceeded than the speed of sound.

For general awareness on some musical instruments were given related to our theory, observe the following images

One word answers

1. If any disturbance created in a medium, then________can be produced.
2. Due to the propagation of waves in a medium, the particles of the medium can be ____
3. The effect of vibration or oscillation of particles of the medium will be depends on ________ property of the medium
4. Waves can be transported________through the medium
5. When sound waves are propagating through the air,________and________regions are formed
6. In a compression region, the particles density is _________and in a rarefaction region the particles density is _______
7. If the particles of the medium vibrates to and fro motion in the same direction of the propagation of the waves are called______________waves
8. If the particles of the medium vibrates perpendicular to the direction of propagation of the waves are called_________waves
9. The mathematical expression of a travelling wave is given by __________
10. The quantity which denotes the maximum displacement of an oscillating particle is called _______
11. The parameter that describes the position and velocity of the oscillating particle at a given instant is called ______
12. The expression which is having a Sine or Cosine function is known as ________ function
13. **Read and answer the below activity in which, what type of waves can be produced.**
    (a) A rope one end is tied to a support and other end is holding by our hand, if hand is moved up and down
    ____
    (b) A sound wave is travelling in air producing compressions and rarefactions
    ____
    (c) A string both ends are tied tightly and on its one end if we make a hit with a stick
    ____
    (d) If a stone is dropped in a still water pool
    ____
    (e) A cylinder filled with air and if a piston pushed forward and backward in it
    ____
14. The restoring force in a stretched string means_________in the string
15. The linear density of a string can be measured as ___________ and its units be _________

16. Teacher-Student activity: Take a long rope and tied its two ends to opposite windows in your class room. Take a wooden stick and hit on its one end, you can observe a pulse produced on the rope that can travel to other end of the rope. With the help of meter scale and stop watch, find the speed of the transverse wave on the rope.

17. According to Newton, in the propagation of sound waves in medium the changes of pressure and temperature will be taking place in________process

18. According to Laplace, in the propagation of sound waves in medium the changes of pressure and temperature will be taking place in________process

19. S.T.P stands for ________

20. At S.T.P the value of pressure is_________and temperature is ___________

21. At S.T.P the speed of sound waves in air is________ m/s

22. The principle of two or more waves combining with each other is called _________

23. Two waves having displacements y_1 and y_2 interfere with each other then the resultant displacement will be ___________

24. The type of interference in which the two waves of same phase overlap with each other then the resultant amplitude increases is known as ____________

25. The type of interference in which the two waves of opposite phase overlap with each other then the resultant amplitude decreases is known as ____________

26. If an incident wave reflected at a rigid boundary can have a phase change of ________

27. If periodical incident and a reflected waves both are overlapped in a cylindrical pipe or string, then the resultant pattern of the wave is known as ___________

28. In standing waves the points at which the amplitude of particles oscillation is zero are called _________

29. In standing waves the points at which the amplitude of particles oscillation is maximum are called _________

30. The possible vibrating frequencies of an oscillating system are called as _________

31. The separation between any two successive nodes or anti nodes is equal to _______

32. The separation between any two successive node and anti node is equal to _______

33. The normal modes of vibration of a stretched string be _________

34. The least frequency of possible modes of a vibrating system is known as _________

35. The expression for the fundamental frequency of a stretched string is _________

36. The organ pipe with one end closed and other open is called ________

37. The harmonic frequencies of a closed pipe be _________

38. The organ pipe opened at both ends is called _________

39. The harmonic frequencies of an open pipe is _________

40. The vibrations of a stretched string or air column of an organ pipe with the effect of vibration of tuning fork over it, are known as ____________

41. The number of beats per second is called ________

42. If two sound waves of 25Hz and 22 Hz are travelling in the same direction and beats are formed due to overlapping, the beat frequency is _________

43. Teacher activity: Read and clarify the reasons to the students.
State which of these represent (i) travelling wave (ii) stationary wave or (iii) none at all

(a) $y = 0.45 \sin(45x - 11t + \pi)$

(b) $y = 2 \cos(3x) \sin(10t)$

(c) $y = 2\sqrt{x - vt}$

(d) $y = 3 \sin(5x - 0.5t) + 4 \cos(5x - 0.5t)$

(e) $y = \cos x \sin t + \cos 2x \sin 2t$

44. Read the following activity and attempt the following questions.

Akash asked by his teacher to take a string of 200 cm length and 5 g mass. Then he tied the string one end to a rigid support and other end is loaded with 2500 g (2.5 kg) weight through a pulley. Then Akash hit on end of the string with a stick and observed the passing of vibrations through the string. (Take acceleration due to gravity $g = 10\ ms^{-2}$)

1. What is the disturbance created by Akash to setup the waves in the string?
2. What type of waves are propagated through the string?
3. What is the linear density of the string taken by Akash?
4. How much tension was produced in the string?
5. What is the speed of the wave propagation in the string?
6. If a stationary wave with fundamental frequency is setup on the entire length of the string, what is that frequency?

45. Read the activity and attempt the following questions

Two students Rajesh and Vinodh asked by their teacher to vibrate loudly the air columns of two closed pipes and found the lengths to be 50 cm and 52 cm with two unknown tuning forks respectively. If two pipes have vibrated with their fundamental frequencies, then

(a) What is the fundamental frequency of the first pipe?
(b) What is the fundamental frequency of the second pipe?
(c) If they have vibrated at the same time, how many beats heard per second?
(d) What will be the phase change of two sound waves when the beats are formed?

46. Give True or False for the following

1. When waves are propagating through a medium, then particles of the medium also can be travelled along with waves. True or False? _________
2. For the propagation of mechanical waves, a medium is necessary. True or False? ______
3. The amplitude of an incident wave at a rigid boundary should be zero. True or False?______
4. The amplitude of the vibration always could be taken as positive. True or False? ______
5. In the standing wave pattern, two nodes or antinodes may be formed successively. True or False? _______
6. For the same length, fundamental frequency of open pipe is always greater than closed pipe. True or False? _______
7. By increasing double the tension in the string, the speed of the wave also be doubled in the string. True or False? _______
8. Doppler effect can be applicable for any speeds of source or observer. True or False? _____
9. Doppler effect can be applicable for sound waves only. True or False?______(T/F)
10. There is a possibility of both longitudinal and transverse waves can be propagated through a medium simultaneously. True or False? _______

47. Read these lines and attempt the following questions. Teacher make sure to give clarifications in every situation to develop the required formula)

Sarala and Vimala both are good friends and they are travelling in a car and a train separately. The speeds of car and train are 90 km/s and 108 km/s, respectively. The train can whistles with a frequency of 600 Hz (take velocity of sound wave in air is 340 m/s)

1. What is the relative velocity between car and train if they are moving in same direction?
2. What is the relative velocity between car and train if they are moving in opposite direction?
3. What is the frequency heard by Sarala, if train is moving towards car? (assume that car is at rest)
4. What is the frequency heard by Sarala if train is moving away from car? (assume that car is at rest)
5. What is the frequency heard by Sarala if the car is moving towards the train? (assume that whistling train is at rest)
6. What is the frequency heard by Sarala if the car is moving away from the train? (assume that whistling train is at rest)

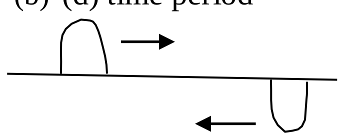
7. What is the frequency heard by Sarala if the car is following the train?
8. What is the frequency heard by Sarala if the train is following the car?
9. What is the frequency heard by Sarala if both car and train are moving towards each other?
10. What is the frequency heard by Sarala if both car and train are moving away from each other?

48. Multiple choice questions

1. The maximum value of the y in the expression in y (x, t) = A Sin (kx-ωt+ϕ) is
   (a) Less than |A| (b) greater than |A| (c) equal to |A| (d) none
2. The condition of obtaining initial phase (ϕ) be ________
   (a) When x = 0 (b) when t = 0 (c) when x = 0 and t = 0 (d) none
3. Identify the correct relation from the following (speed of mechanical waves in different media)

   (a). $V_{solid} > V_{liquid} < V_{gases}$ (b) $V_{solid} > V_{liquid} > V_{gases}$

   (c) $V_{solid} < V_{liquid} < V_{gases}$ (d) $V_{solid} > V_{liquid} < V_{gases}$

4. The speed of the sound waves in solids is more because
   (a) Compressibility of solids is difficult and hence their bulk modulus is high
   (b) Compressibility of solids is difficult and hence their bulk modulus is low
   (c) Compressibility of solids is easy and hence their bulk modulus is high
   (d) Compressibility of solids is easy and hence their bulk modulus is low
5. The main factor which effects the speed of the sound wave is the __
   (a)Amplitude (b) intensity (c) frequency (d) medium elastic property
6. The number of cycles occurring per unit time of a periodic wave is called ________
   (a) frequency (b) amplitude (c) Wavelength
   (b) (d) time period
7.  Chose the correct statements when they overlapped,
   (a) Both pulses are in same phase ($\phi = 0^o$) and their amplitudes will be added
   (b) Both pulses are in opposite phase ($\phi = 180^o$) and their amplitudes will be subtracted
   (c) Both pulses are in same phase ($\phi = 0^o$) and their amplitudes will be subtracted
   (d) Both pulses are in opposite phase ($\phi = 180^o$) and their amplitudes will be added

8. If y_i (x, t) = Asin (kx-ωt) be the incident wave on a rigid boundary then its reflected wave can be expressed as
   (a) y_r (x, t) = A Sin (kx-ωt)
   (b) y_r (x, t) = A Sin (kx-ωt+π)
   (c) y_r (x, t) = A Sin (kx-ωt+π/2)
   (d) y_r (x, t) = A Sin (kx-ωt+2π)
9. One waxing and one waning constitute ________
   (a) one beat (b) two beats (c) half beat (d) no beat
10. In perfect tuning the strings of a guitar or a violin, the pitch of the beat frequency should be _______
   (a). increased and maximized (b) decreased and minimized
   (c) Completely nullified (d) no effect of beats in tuning
11. Doppler effect should be taking place whenever the condition is satisfied _______
   (a) If the sound emitting source and observer both are stationary
   (b) If the source and observer both are in motion with same velocities
   (c) If the source or observer or both are in motion with different velocities
   (d) None of the above
12. If a clarinet and a flute having equal lengths were played then ___________
   (a) The note of clarinet is always less than that of flute
   (b) The note of flute is always less than that of clarinet
   (c) The notes of flute and clarinet are always equal
   (d) None of the above
13. Beats phenomenon is the resultant of _________
   (a) Constructive interference of sound waves
   (b) destructive interference of sound waves
   (c) both constructive and destructive interference of sound waves
   (d) none of the above
14. If the prongs of the tuning fork were loaded with a little wax, its frequency will be ___
   (a) increases (b) decreases (c) may increase or decrease (d) not altered
15. When the two tuning forks A and B are sounded together, x beats per second produced. If frequency of A is n, the frequency of B will be ________
   (a) n-x (b) n+x (c) ether of (a) or (b) (d) n^x
16. As the atmosphere temperature increases, the frequency of the vibrating tuning fork ________
   (a) Slightly increases (b) slightly decreases (c) no change (d)may increase or decrease

Match the following

49. Match the following parameters with their names , from y(x,t)=Asin(kx-ωt+ϕ)

1. y (x,t)	( )	(A) phase angle
2. A	( )	(B) wave number
3. K	( )	(C) Amplitude
4. ω	( )	(D) wave function
5. ϕ	( )	(E) angular frequency
6. (kx-ωt+ϕ)	( )	(F) initial phase

50. Match the following quantities with their units

1. Wavelength (λ)	( )	(A) meter/second
2. Frequency (ν)	( )	(B) meter
3. Wav number (k)	( )	(C) radian
4. Angular frequency (ω)	( )	(D) hertz
5. Phase of Oscillation (ϕ)	( )	(E) radian/meter
6. Wave velocity (v)	( )	(F) radian/second

51. Match the following quantities with their equivalent expressions

1. Wave number (k)	( )	(A) ω/2π
2. Frequency (ν)	( )	(B) λ/T
3. Time period (T)	( )	(C) 2πν
4. Angular frequency (ω)	( )	(D) 2π/λ
5. Wave velocity (v)	( )	(F) 2π/ω

52. Match the following speed of waves in different media with their formulae

1. Speed of transverse waves in a string	( )	(A) $\sqrt{\frac{\gamma P}{\rho}}$
2. Speed of longitudinal waves in medium	( )	(B) $\sqrt{\frac{P}{\rho}}$
3. Speed of longitudinal waves in a solid rod	( )	(C) $\sqrt{\frac{T}{\mu}}$
4. Speed of longitudinal waves in gases (Newton's formula)	( )	(D) $\sqrt{\frac{Y}{\rho}}$
5. Speed of longitudinal waves in gases (Laplace correction)	( )	(E) $\sqrt{\frac{B}{\rho}}$

53. Match the following musical instruments with their types

1. guitar, violin	( )	(A) open pipes
2. flute, trumpet	( )	(B) musical pillars(Nellaiappar temple)
3. those produce shruthi , laya tunes	( )	(C) string instruments
4. clarinet, saxophone	( )	(D) closed pipes

54. Student Activity: Solve the following exercises (teacher shall guide and advice)

1. A progressive wave is represented by the equation y(x,t)= 0.5 Sin(120x-80t+π/3) m, then find (a) initial displacement (b) initial phase (c) amplitude (d) angular frequency and wave number (e) speed of the wave (f) wavelength (f) time period

2. A harmonic wave on a string is given by y(x,t) = 3.0 sin (36t + 0.314x + π/4)

(a) is the wave is a stationary wave or a travelling wave?

(b) what is the amplitude and frequency?

(c) what is the separation between any two successive crests or troughs?

(d) what is the wavelength of the wave?

3. A string of mass 2.50 kg is under a tension of 200 N. The length of the stretched string is 20 m. If the transverse jerk is struck at one end of the string, how long does the disturbance take to reach the other end?

4. How do you satisfy that the speed of the sound in air often proposed by Laplace will give much better result than the Newton?

5. Using the formula, $= \sqrt{\frac{\gamma P}{\rho}}$, how can you justify that the speed of sound wave in air is

(a) independent of pressure (b) increase with temperature (c) increase with humidity

6. A bat emits ultrasonic sound of frequency 1000 KHz in air. If this sound meets a water surface, what is the wavelength of (a) the reflected sound (b) transmitted sound? (Speed of the sound in air is 340 m/s and in water is 1486 m/s)

7. A hospital uses an ultrasonic scanner to locate tumors in a tissue. If the operating frequency of the scanner is 4.2 MHz, what is the wavelength of the sound in a tissue in which the speed of the sound is 1.7 km/sif the speed of the sound?

8. Two tuning forks of A and B when sounded together produce 4 beats. If A and B are in unison with 0.96 m and 0.97 m lengths of same wire with same tension. Find the frequencies of the A and B forks.

9. A note produces 7 beats with tuning fork of frequency 256 Hz and 3 beats with tuning fork of frequency 266 Hz. Find the frequency of the note

10. A SONAR system fixed in a submarine operates at a frequency 40.0 KHz. An enemy submarine moves towards the SONAR with a speed of 360 kmph. What is the frequency of the sound reflected by the submarine? (Take the speed of the sound in water to be 1450 m/s)

WAVES - KEY:

1. waves
2. oscillations or vibrations
3. elastic
4. energy
5. compressions and rare factions
6. high, low
7. longitudinal
8. transverse
9. $y(x,t) = A\sin(kx - \omega t)$
10. amplitude
11. phase
12. harmonic
13. (a) transverse (b) longitudinal(c) transverse (d) longitudinal and transverse (e) longitudinal
14. Tension
15. Mass/length
16. Activity
17. Isothermal
18. Adiabatic
19. Standard Temperature and Pressure
20. P = 1 atm and T = 0 ^oC
21. 331 m/s
22. Superposition or interference
23. $y = y_1 + y_2$
24. constructive
25. destructive
26. 180^o or π rad
27. Stationary or standing
28. Displacement nodes or pressure antinodes
29. Displacement anti nodes or pressure nodes
30. Normal modes
31. $\lambda/2$
32. $\lambda/4$

34. closed
37. $\nu \; = (n + {}^{1})^{nv}$ for n=0,1,2,3,…..
38. Open
39. $\nu_n = \frac{nv}{2L}$ for n=1,2,3,…
40. Forced vibrations
41. Beat frequency
42. 3 Hz
43. (a) travelling (b) stationary (c) none (d) two travelling waves overlapped (e) two stationary waves overlapped
44. (1) Hitting on the string with a stick (2) Transverse waves (3) $\mu = \frac{m}{l} = 2.5 \times 10^{-3}$ kg/m (4) T = mg = 25 N (5) $v = \sqrt{\frac{T}{\mu}} = 100\ m/s$ (6) $\nu_1 = \frac{v}{2L} = 25\ Hz$
45. (a) 170 Hz (b) 164 Hz (c) 6 beats/second (d) 0^0 in waxing(same phase) and 180^0 in waning(out of phase) conditions
46. (1) F (2) T (3) T (4) T (5) F (6) T (7) F (8) F (9) F (10) T

47. (1) 18 kmph or 5 m/s (2) 198 kmph or 55 m/s (3) 658 Hz (4) 551 Hz (5) 644 Hz (6) 556 Hz (7) 592 Hz (8) 610 Hz (9) 706 Hz (10) 511 Hz

48. (1) c (2) c (3) b (4) a (5) d (6) a (7) b (8) b (9) a (10) c (11) c (12) a (13) c (14) b (15) c (16) b

49. (1) D (2) C (3) B (4) E (5) F (6) A

50. (1) B (2) D (3) E (4) F (5) C (6) A

51. (1) D (2) A (3) F (4) C (5) B

52. (1) C (2) E (3) D (4) B (5) A

53. (1) C (2) A (3) B (4) D

54. 1 (a) 0.433 m (b) π/3 rad (c) 0.5 m (d) ω = 80 rad/s, k = 120 rad/m (e) 0.67 m/s (f) 0.052 m (g) 0.078 s
2. (a) travelling wave from left to right (b) 3 cm and 5.73 Hz (c) π/4 rad (d) λ = 20 cm

3. $\mu = \frac{m}{l}$ = 0.125 kg/m, $v = \sqrt{\frac{T}{\mu}} = 40\ m/s$, t = l/v = 0.5 s

4. According to Newton, $v = \sqrt{\frac{P}{\rho}}$ = 280 m/s

According to Laplace, $v = \sqrt{\frac{\gamma P}{\rho}}$ = 331 m/s

5. i) $v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$ hence at constant temperature, v is constant, independent of pressure

ii) Since $v \propto \sqrt{T}$, as temperature increases speed also increases

iii) As humidity increases, density of the air decreases

Since $v \propto \frac{1}{\sqrt{\rho}}$ if density decreases, speed of sound increases

6. (a) $\lambda_{air} = 3.4 \times 10^{-4}$m, (b) $\lambda_{water} = 14.86 \times 10^{-4}$ m

7. $\lambda = 4.05 \times 10^{-4}$ m

8. $n_2 = 384\ Hz$

(Hint: $n_1 - n_2 = 4$ and $n_1 l_1 = n_2 l_2$)

9. 263 Hz

10. When incident sound wave strikes the submarine, apparent frequency $\nu_i = 43KHz$
When reflected sound wave strikes the SONAR, apparent frequency $\nu_r = 46KHz$

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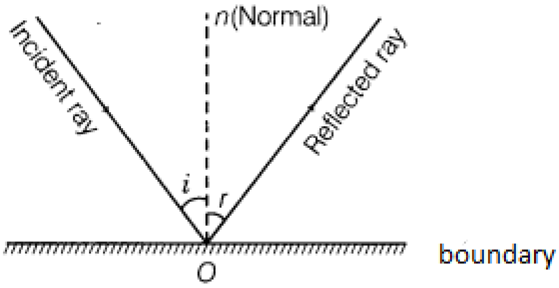
RAY OPTICS AND OPTICAL INSTRUMENTS

Light : Light is a form of energy which is emitted by luminous body and when incident on the eye causes the sensation of vision through nerves. Speed of light in vacuum is 3×10^{8} m /sec.

Reflection of light : When a ray of light after incidenting on boundary separating two media comes back into the same media then this phenomenon is called reflection of light.

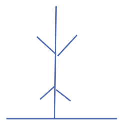


Laws of Reflection : 1. Angle of incidence (i) = Angle of reflection (2)

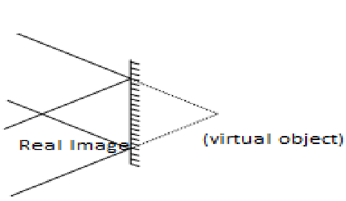
2. The incident ray , reflected ray and normal are always in same plane.

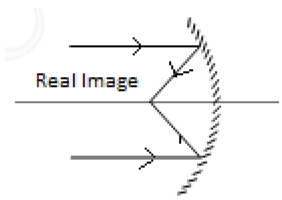
After reflection velocity, wavelength and frequency of light remains same but intensity decreases.

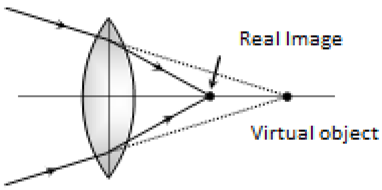
If light ray incident normally on surface after reflected it retraces the path.

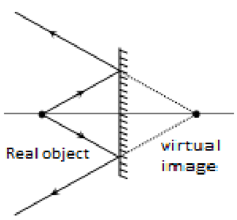


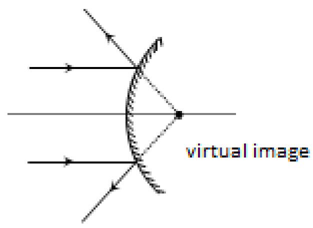
Real and virtual images : If light rays, after reflection and refraction actually meets at a point then real image is formed, and if they appears to meet virtual image is formed.

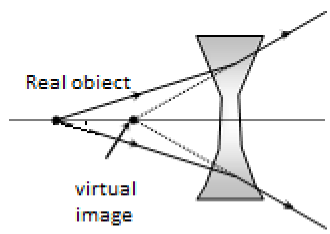








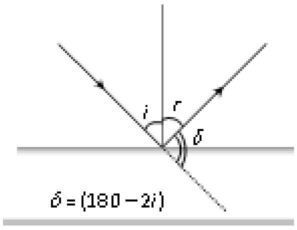


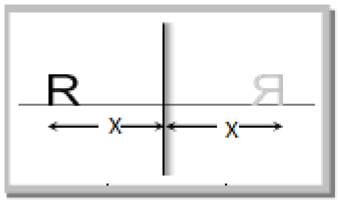


Reflection from plane surface

Plane mirror : Plane mirror has infinitely large radius of curvature. It produces virtual image, erect laterally inverted, equal in size. That of the object and at a distance equal to the distance of the object in front of the mirror.

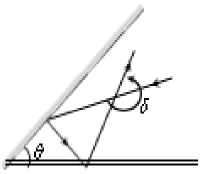
a) **Deviation by plane mirror :** Deviation is the angle between direction of initial and final rays .



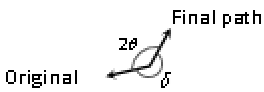


Angle of deviation δ = (180 – 2i) = (180 – 2θ)

Deviation by two inclined plane mirrors :

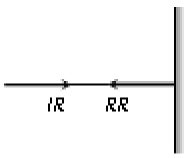


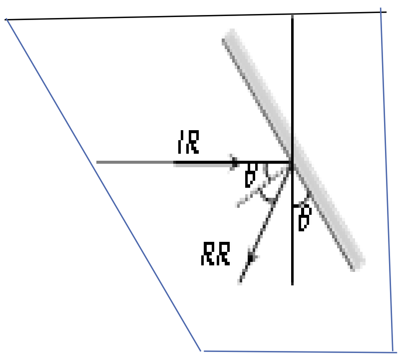
δ = (360 – 2θ)



(a) If two plane mirrors are inclined to each other at 90^0 at the emergent rays is anti parallel to incident rays. If it suffers one reflection from each what ever be the angle of incidence.

(b) **Rotation :** If a plane mirror is rotated in the plane of incidence through angle by keeping the incident ray fixed ,the reflected ray turned through an angle θ.





b) **Images by two inclined plane mirrors :** When two plane mirrors are inclined to each other at an angle θ then number of images (n) formed of an object which is represented between them

If $n = \left(\frac{360^0}{\theta} - 1\right)$ if $\frac{360^0}{\theta}$ = even integer

if $\frac{360^0}{\theta}$ = odd integer than there are two possibilities.

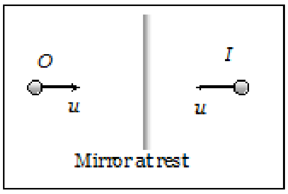
2(a) = object is placed Symmetrically

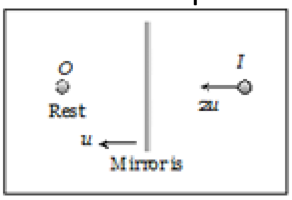
$$n = \left(\frac{360^0}{\theta} - 1\right)$$

2(b) = object is placed asymmetrically

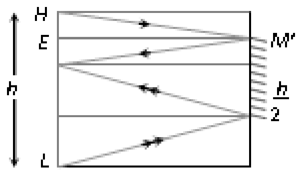
$$n = \frac{360^0}{\theta}$$

- If θ = 0 then mirrors are parallel to each other.
  $\therefore \theta = 0 \Rightarrow \alpha \rightarrow$ infinite images will be formed
- If $\theta = 90 \Rightarrow n = \left(\frac{360^0}{\theta} - 1\right) = (4 - 1) = 3$
- If an object moves with speed μ towards (or away) from the plane mirror then image also moves toward (or away) with speed μ .But relative speed of image *w.r.t.* object is 2*u.*
- When mirror moves towards the stationary object with speed *u*, the image will move with speed 2*u*.

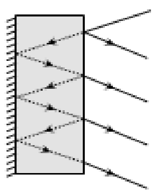




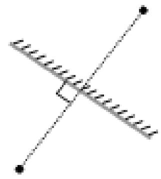
- A man of height *h* requires a mirror of length at least equal to *h*/2, to see his own complete image.
- To see complete wall behind himself a person requires a plane mirror of at least one third the height of wall. It should be noted that person is standing in the middle of the room.



- The reflection from a denser medium causes an additional phase change of **π** or path change of **π** /2 while reflection from rarer medium doesn't cause any phase change.
- We observe number of images in a thick plane mirror, out of them only second is brightest.



- To find the location of an object from an inclined plane mirror, you have to see the perpendicular distance of the object from the mirror.



MIRROR FORMULA AND MAGNIFICATION :

For a spherical mirror

If μ = distance of object from pole, V = distance of image from pole

F = focal length R = radius of curvature

O = size of object i = size of image

M= magnification (of linear magnification)

M_g = areal magnification A_o = Area of object

A_i = Area of Image

Mirror formula $\boxed{\frac{1}{f} = \frac{1}{\mu} + \frac{1}{v}}$ (sign convention while solving problems)

- Newton's formula : If object distance (x_1) and image distance (x_2) are measured from focus instead of pole then $f^2 = x_1 x_2$

  Magnification (m) = $\frac{size\ of\ objecct}{size\ of\ image}$ $\mu = f + x_1$, $V = f + x_2$

Linear Magnification

Transverse

When an object is placed

If a 2D object is placed

Perpendicular to the principle

Axis then linear magnification is

Is called lateral or transverse

Magnification . It is given by

$$\mathbf{M} = \frac{I}{o} = \frac{v}{\mu} = \frac{f}{f-\mu}$$

$$= \frac{f-V}{f}$$

Longitudinal

When object lies along

the principle axis then its

longitudinal magnification

If $m = \frac{I}{o} = \frac{(V_2-V_1)}{(\mu_2-\mu_1)}$

If object is small

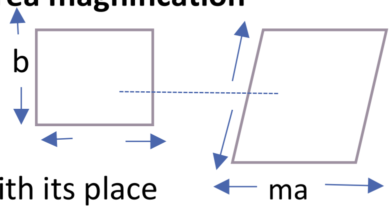
$$\boxed{M = \frac{dV}{d\mu} = (\frac{V}{\mu})^2}$$

Length of image

$= \frac{V^2}{\mu^2}$ x length of object (L_o)

$$L_I = [\frac{f}{\mu-f}]^2 L_o$$

Area magnification



with its place

perpendicular to

principle axis

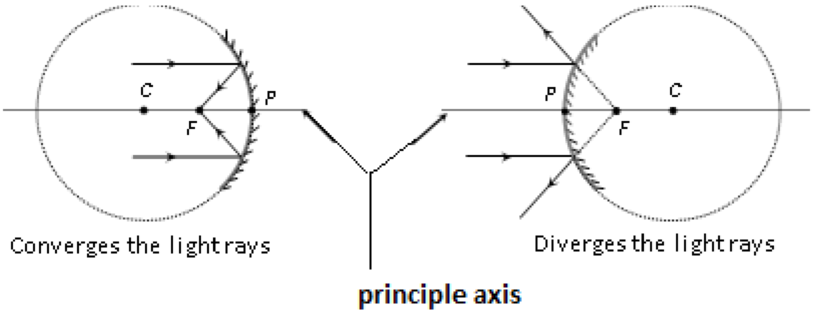
It's a real magnification

$$\boxed{M_s = \frac{Area\ of\ image\ A_i}{Area\ of\ object\ A_o}}$$

$$= \frac{m_a\, x\, m_b}{a\ x\ b} = m^2$$

$$M_s = m^2 = \frac{Ai}{Ao}$$

Curved mirror :



It is a part of a transparent hollow sphere whose one surface is polished.

Definitions :

(i)Pole (P) :The geometrical center of the spherical surface of the mirror (or) Mid point of the mirror

(ii)Centre of curvature (C) : Centre of the sphere of which the mirror is a part.

(iii)Radius of curvature (R): Distance between pole and centre of curvature

$$R_{concave} = -ve\ ,\ R_{convex} = +ve\ ,\ R_{plane} = \alpha$$

(iv)Principle axis : A line passing through *P* and *C*.

(v)Focus (F) : An image point on principle axis for which object is at α.

(vi)Focal length (f) : Distance between *P* and *F*.

(vii)Relation between F and R : $f = \frac{R}{2}$ $f_{concave} = -ve$

$f_{convex} = +ve$

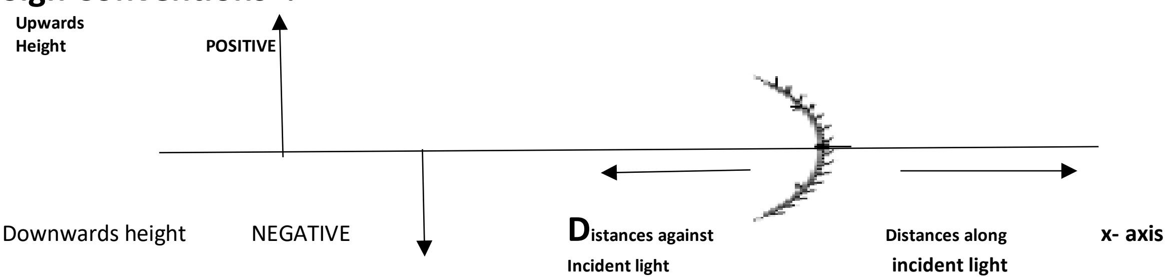
$f_{plane} = \alpha$

(viii) Power : The converging or diverging ability of mirror

(ix)Aperture : Effective diameter of light reflecting area.

Intensity of image α Area α $(Aperture)^2$

Sign Conventions :



(1) All distances are measured from the pole

(2)Distances measured in the direction of incident rays are taken as positive while in the direction opposite of incident rays are taken negative.

(3) Distances above the principle axis are taken positive andbelow the principle axis are taken negative.

(4) Same sign convention are also valid for lenses.

Image formed by Concave mirror

Position of object	Position of image	Magnification	Nature of Image
Between P and F	Behind the mirror	+ ve m > 1	Virtual & erect
At F	At infinity	- ve highly magnified	Real & inverted
Between F and C	Beyond C	-ve magnified	Real & inverted
At C	At C	m = -1	Real & inverted
Beyond C	Between F and C	Diminished	Real & inverted
At infinity	At F	Highly diminished	Real & inverted

Image formed by convex mirror

Position of object	Position of image	Magnification	Nature of Image
In front of mirror	Between P and F	M < + 1	Virtual & erect
At infinity	At F	M << + 1	Virtual & erect

Uses of mirrors

(a) **Concave mirror** : (1) Used as a shaving mirror.

(2) Used as a telescope by ENT specialist

(3) Used as in cinema projector

(4) Used as reflector in torch, search light , heat light of automobiles , car's etc.

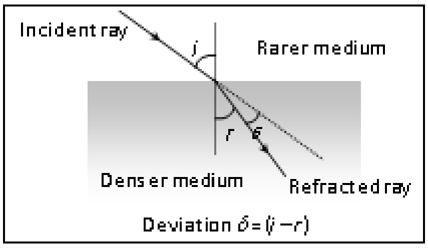
(b) **Convex mirror:**

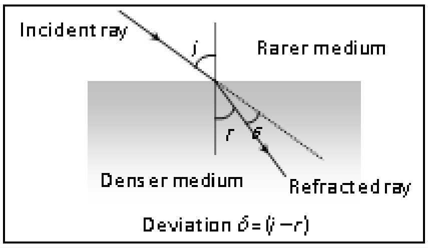
(1) Used as a reflector in street lamps.

(2) Used as a side mirror in vehicles.

- Field of view of convex mirror is more than that of concave mirror and convex mirror provides a much wider field of view as compared to a plane of the same size.

Refraction : The bending of the ray of light passing from one medium to the other medium is called refraction.





Snell's Law : The ratio of sine of the angle of incidence to the angle of refraction (r) is a constant called refractive index.

$\mu = \frac{\sin i}{\sin \gamma}$, $u_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin \gamma} \Rightarrow u_1 \sin i = u_2 \sin \gamma$

∴ $u \sin \theta = \text{constant}$

Refractive Index : Refractive index of a medium is that characteristic which decides speed of light in it. It is scalar, unit less and dimensionless quantity.

(a) **Absolute refractive index :** (i) When light travels from air to any transparent medium then R.I. of medium *w.r.t.* air is called it's absolute R. I $_{air}\mu_{medium} = \frac{c}{v}$

Ex. $_{air}\mu_{glass} = 1.5$ $_{air}\mu_{water} = 1.3$

$_{air}\mu_{crown} = 1.52$ $\mu_{diamond} = 2.4$

$\mu_{vaccum} = 1$ $\mu_{air} = 1.003$

(b) **Relative refractive index :** When light travels from medium (1) to medium (2) then R.I. of medium (2) *w.r.t.* medium (1) is called Relative R. I.

$\mu_2 = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$

Ex . $_w u_g = \frac{\mu_g}{\mu_w} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{9}{8}$

- Cauchy's equation $\mu = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots$ $\lambda_{Red} > \lambda_{violet}$

  $\mu_{real} < \mu_g$

$\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\lambda_1}{\lambda_2} = \frac{v_2}{v_1}$

$\mu \propto \frac{1}{\lambda}$, $\mu \propto \frac{1}{v}$, $v \propto \lambda$

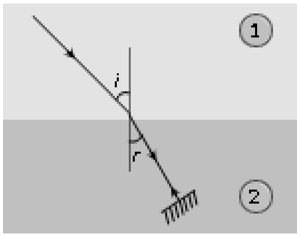
Dependence of Refractive index

(i) Nature of the media of incidence and refraction.

(ii) Colour of light or wave length of light.

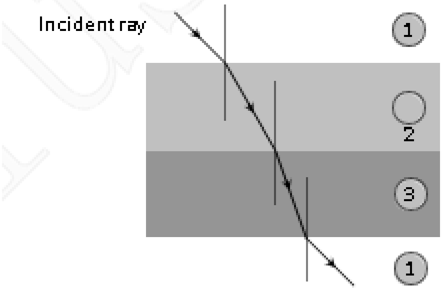
(iii) Temperature of the media : Refractive index decreases with the increase in temperature

Principle of reversibility



Refraction through several media

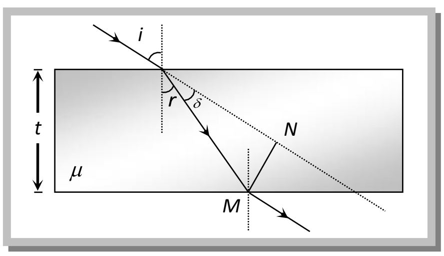
Refraction through several media



${}_1\mu_2 \times {}_2\mu_3 \times {}_3\mu_1 = 1$

Refraction through a glass slab and optical path :

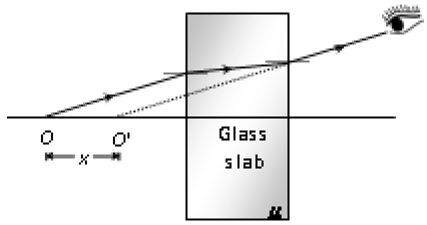
(1)Lateral shift : The refracting surfaces of a glass slab are parallel to each other. When a light ray passes through a glass slab it is refracted twice at the two parallel faces and finally emerges out parallel to it's incident direction *i.e.* the ray undergoes no deviation $\delta = 0$. The angle of emergence (e) is equal to the angle of incidence (i)



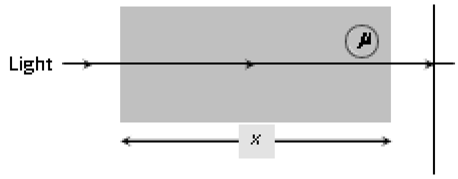
Normal shift : OO' = x = $\left(1 - \frac{1}{\mu}\right)$ t

The object appears to be shifted towards

the slab by the distance.



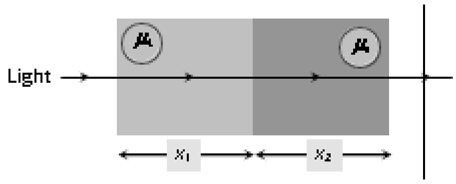
Optical path : It is defined as distance travelled by light in vacuum in the same time in which it travels agiven path length in a medium.



Time taken by light ray to pass through the medium

= $\frac{\mu x}{C}$ optical path , μ x – optical path , x - geometrical path

Optical path for two mediums in contact



= $\mu_1 x_1 + \mu_2 x_2$

Note : For all media u > 1 so optical path length (ux)

always greater than the geometrical path length (x)

Real and apparent depth : If object and observer are situated in different medium then due to refraction, object appears to be displaced from it's position. There are two possible conditions.

(i) When object is in denser medium and observer is in rarer medium

(ii) Object is in rarer medium and observer is in denser medium.

(2)Real depth > apparent depth that's why a coin at the bottom of bucket (full of water) appears to be raised	(2) Real depth < apparent depth that's why high flying aeroplane appears to be higher than its actual height.
(3) Shift δ = h – h' = $(1 - \frac{1}{\mu})$ h	(3) d = (μ -1)h
(4) For water μ = $\frac{4}{3}$ ⇒ d = $\frac{h}{4}$	(4) shift for water $d_w = \frac{h}{3}$
For glass μ = $\frac{3}{2}$ ⇒ d = $\frac{h}{3}$	Shift for glass dy = $\frac{h}{2}$

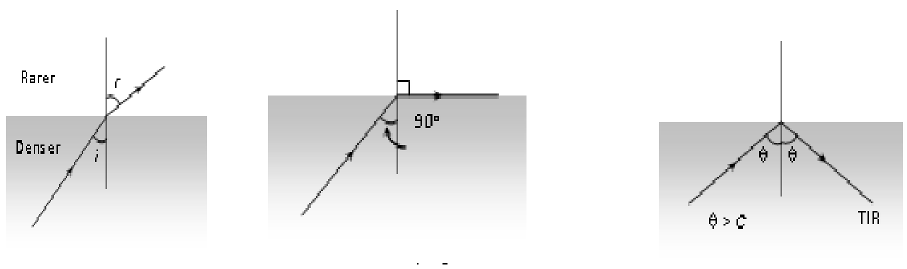
Total internal Reflection :

When a ray of light goes from denser to rarer medium it bends away from the normal and as the angle of incidence in denser medium increases, the angle of refraction in rarer medium also increases and at a certain angle, angle of refraction becomes 90^o, this angle of incidence is called critical angle (*C*).

When angle of incidence exceeds the critical angle than light ray comes back in to the same mediumafter reflection from interface. This phenomenon is called Total internal reflection (TIR).

$$\boldsymbol{\mu = \frac{1}{\sin c}}$$

Where μ → rerer μ_{denser} , C – Critical angle



If a light travels from denser to rarer medium, then deviation of the ray is

$$\delta = \pi - 2\theta \Rightarrow \delta \rightarrow \text{max. when} \theta \rightarrow \text{min.} = C$$

i.e. $\delta_{max} = (\pi - 2C)$; $C \rightarrow$ critical angle

Dependence of critical angle :

(i) **Colour of light (wave length of light) :** Critical angle depends upon wave length as $\lambda \; \alpha \; \frac{1}{\mu} \; \alpha \; \sin c$

(i) $\lambda_R > \lambda_V \Rightarrow C_R > C_V$

(ii) $\sin c = \frac{1}{R\,\mu_D} = \frac{\mu_R}{\mu_D} = \frac{\lambda\, D}{\lambda\, R}$

(ii) **Nature of the pair of media :** Greater the refractive index lesser will be the critical angle.

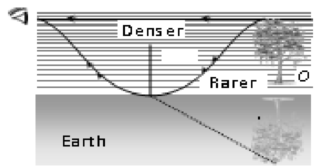
(i) For (glass – air) pair → $C_{Glass} = 42^0$

(ii) For (Water – air) pair → $C_{Water} = 48.75^0$

(iii) For (Diamond -air) pair → $C_{Water} = 24.41^0$

(iii) **Temperature :** With temperature and refractive index of the material decreases therefore critical angle increases.

Examples of total internal reflection :



1) **Mirage :** In hot summer days, the air near the ground becomes hotter than the air at higher levels. The refractive index of air increases with its density. Hotter air is less dense and has smaller refractive index than cooler air. If the air currents are small that is the air is still the optical density at different layers of air increases with height. To a distant observer the light appears to be coming from somewhere below the ground. The observer naturally assumes that light is being reflected from the ground say by a pool of water near the tall object . Such inverted images of distant tall objects cause an optical illusion to the observer. This phenomenon is called mirage.

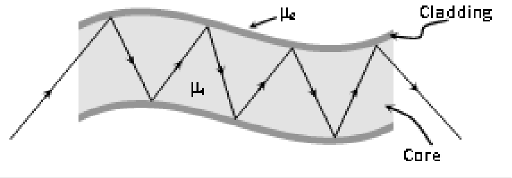
2) **Brilliance of Diamond :** Due to repeated internal reflections diamond sparkles.

The critical angle for diamond-air interface = 24.4^0 is very small. Therefore once light enters a diamond, it is very likely to undergo total internal reflection inside it. Diamonds found in nature rarely exhibit the brilliance for which they are known. It is the technical skill of diamond cutter which makes diamonds to sparkle so brilliantly by cutting the diamond suitably multiple total internal reflections can be made to occur.

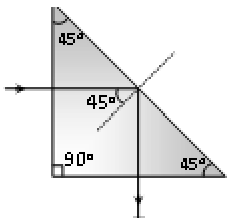
3) **Optical fibre :** Optical fibres consist of many long high quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core (μ_1) is higher than that of the cladding (μ_2).

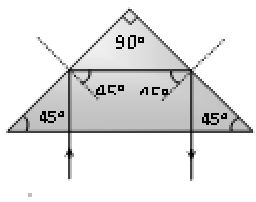
When the light is incident on one end of the fibre at a small angle, the light passes inside, undergoes repeated total internal reflections along the fibre and finally comes out. The angle of incidence is always larger than the critical angle of the core material with respect to its cladding. Even if the fibre is bent, the light can easily travel through along the fibre.

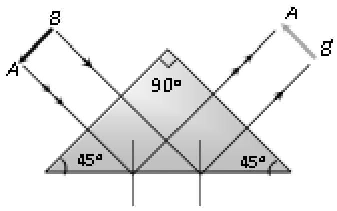
Uses : A bundle of tical fibres can be used as a 'light pipe' in medical and optical examination. It can also be used for optical signal transmission. Optical fibres have also been used for transmittingand receiving electrical signals which are converted to light by suitable transducers.



Prism : A right angled isosceles prism, which is used in periscopes or binoculars.It is used to deviate light rays through 90^o and 180^o and also to erect the image.







Refraction from curved surface :

μ_1 = Refractive index of the medium from which light rays are coming (from object).

μ_2 = Refractive index of the medium in which light rays are entering.

μ = Distance of object , V = Distance of image

R = Radius of curvature

Refraction formula : $\frac{\mu_2-\mu_1}{R} = \frac{\mu_2}{V} - \frac{\mu_1}{\mu}$

- Real image forms on the side of refracting surface. That is opposite to the object and virtual image forms on the same side as the object.

Lateral (transverse) magnification m = $\frac{I}{0} = \frac{\mu_1 V}{\mu_{2\,\mu}}$

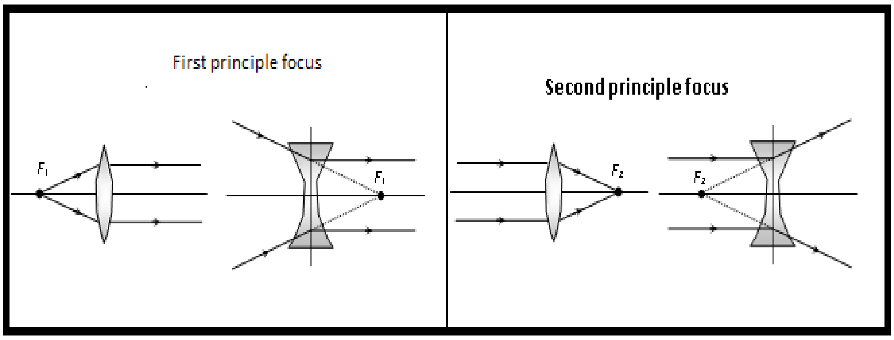
Lens : Lens is a transparent medium bounded by two refracting surfaces such that at least one surface is spherical.

Convex lens : It converges the light rays and it forms real and virtual images only.

Concave lens : It diverges the light rays and it forms only virtual images.

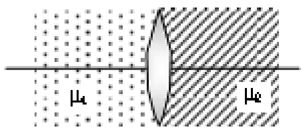
Optical centre (o) : point for a given lens through which light ray passes undeviated . (light ray passes undeviated through optical centre).

Principle focus :



- Second principle focus is the principle focus of the lens when medium on two sides of lens is same then
- If medium on two sides of lens are not same then the ratio of two focal lengths

$$\frac{f_1}{f_2} = \frac{\mu_1}{\mu_2}$$



Focal length (*f*) : Distance of second principle focus from optical centre is called focal length

$f_{convex} \rightarrow$ positive $f_{concave} \rightarrow$ negative $f_{plane} \rightarrow \infty$

Apperture : Effective diameter of light transmitting area is called aperture.

Intensity of image α $(\text{aperture})^2$

Power of lens (P) : means the ability of a lens to converge the light ray. Unit of power is Diopter (D)

$P = \frac{1}{f\,(m)} = \frac{100}{f\,(m)}$ P_{convex} → positive $P_{concave}$ →negative

P_{plane} → zero

Lens Maker's formula : The relation between is known as lens makers formula

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{K_1} - \frac{1}{R_2}\right]$$

Lens formula and magnification of lens.

(i) Lens formula : $\frac{1}{f} = \frac{1}{V} - \frac{1}{\mu}$

(ii)Magnification : The ratio of the size of the image to the size of object is called magnification.

(iii) Transverse magnification : $m = \frac{I}{0} = \frac{v}{\mu} = \frac{f}{f+\mu} = \frac{f-v}{f}$

(iv) Longitudinal magnification : $m = \frac{I}{0} = \frac{V_2 - V_1}{\mu_2 - \mu_1}$

(v) For very small object $m = \frac{d\,V}{d\,\mu} = \left(\frac{V}{\mu}\right)^2 = \left(\frac{f}{f+\mu}\right)^2 = \left(\frac{f-v}{f}\right)^2$

(vi) Area magnification $m_s = \frac{A_i}{A_0} = m^2 = \left(\frac{f}{f+\mu}\right)^2$

A_i → Area of image

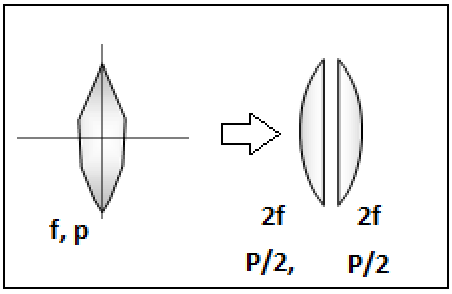
A_0 → Area of object

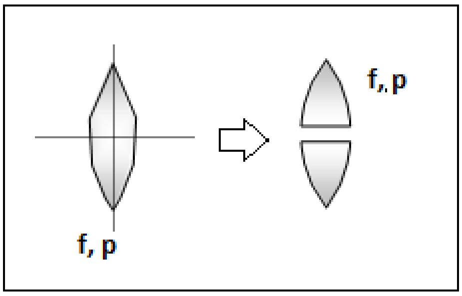
Relation between object and image speed : If an object move with constant speed (V_0) towards a convex lens from infinity to focus the image will move slower in the beginning and then faster.

$$V_i = \left(\frac{f}{f+\mu}\right)^2 V_0$$

Cutting of lens : (1) A symmetric lens is cut along optical axis in two equal parts, intensity of image formed by each part will be same as that of complete lens.

(2)A symmetrical lens is cut along principle axis in two equal parts, intensity of image formed by each part will be less compared as that of complete lens. (aperture of each part is $\frac{1}{\sqrt{2}}$ times that of complete lens).





Combination of lens : If several thin lenses of focal length f_1, f_2, f_3………. are in contact, the effective focal length of their combination is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \cdots$$

The total power of a combination of several lenses is

$P = P_1 + P_2 + P_3 + \ldots\ldots\ldots\ldots\ldots$

And $m = m_1 \times m_2 \times m_3 \times \ldots\ldots\ldots\ldots\ldots\ldots$

(a) In case when two thin lens are in contact, then $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow F = \frac{f_1 f_2}{f_1 + f_2}$

And $P = P_1 + P_2$

(b) If two lens of equal focal length but of opposite nature are in contact then combination behaves as a plane glass plate and

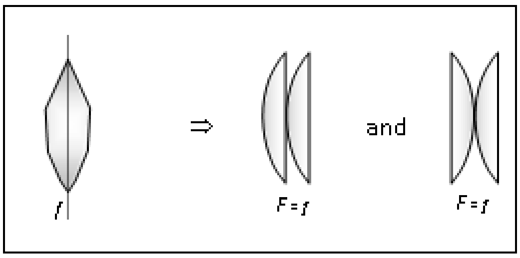
$F_{combination} = \alpha$

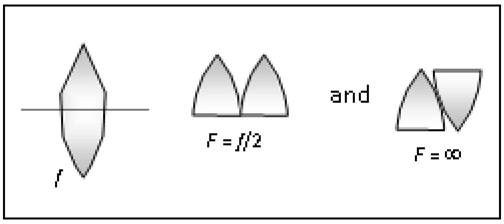
(c)When two lenses are placed co-axially at a distance from each other, then equal focal length

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{f}{f_1 f_2}$$

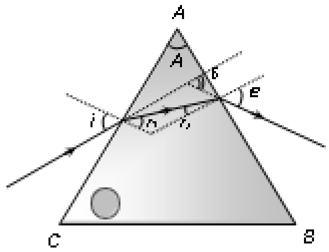
$$P = P_1 + P_2 - d\,P_1 P_2$$

(d) **Combination of parts of lens**





Refraction through prism :



A = Angle of prism γ_1, γ_2 are angle of refraction

i – Angle of incidence δ = Angle of deviation

e – angle of emergence

$\mu = \frac{\sin(\frac{A+\delta m}{2})}{\sin(\frac{n}{2})}$ A = n + γ_2 & i + e = r + δ

For surface AC, $\mu = \frac{\sin i}{\gamma_1}$

For Surface AB $\mu = \frac{\sin \gamma^2}{\sin e}$

Deviation through prism

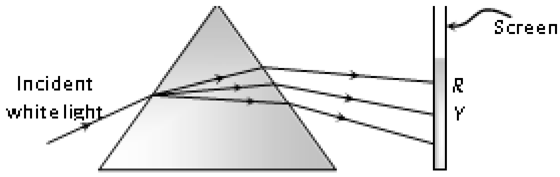
For thin prism deviation $\delta = A(\mu - 1)$

$\mu_R < \mu_V$ so $\delta_R < \delta_V$

Dispersion through prism : The splitting of white light in to its constituent colours is called dispersion of light.

(1) Angular dispersion (θ) : Angular separation between extreme colours.

$\theta = \delta_V - \delta_R = (\mu_V - \mu_R) A$



2) Dispersive power (w) = $\frac{\theta}{\delta y}$

It depends only upon the material of the prism u and it does not depend upon angle of prism.

$W_{flint} > w_{crown}$

Scattering of light : Molecules of a medium after absorbing incoming light radiations, emits them in all directions. This phenomenon is called Scattering.

(a) According to scientist Rayleigh :

Intensity of scattered light α $\frac{1}{\lambda^4}$

(b) Some phenomenon based on scattering :

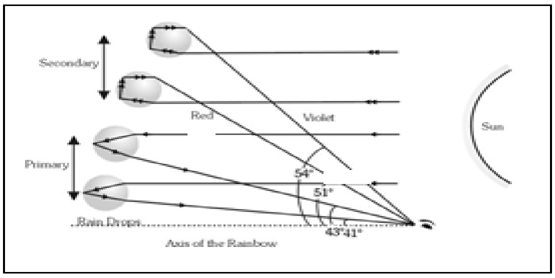
(i) Sky looks blue due to scattering.

(ii) All the time of sunrise or sunset it looks reddish.

(c)Elastic scattering : When the wavelength of radiation remains unchanged, the scattering is called elastic scattering.

(d)Inelastic scattering (Raman's effect) : Under specific condition, ight can also suffer inelastic scattering from molecules in which it's wavelength changes.

Rainbow : Rainbow is formed due to the dispersion of light suffering refraction and TIR in the droplets present in the atmosphere.



Primary rainbow :

(1) Two reflections and one TIR

(2)Inner most are is violet and outer most is red.

(3)Subtends an angle of 42 at the eye of observer

(4)More bright

Secondary rainbow :

(1) Two refraction and two TIR,

(2) Inner most are is red and outer most is violet.

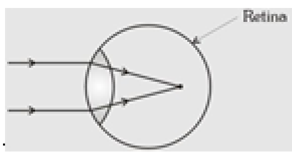
(3) It subtends an angle of 52.50 at the eye.

(4) comparatively less bright.

Defects in eye :

Myopia (short sightness)

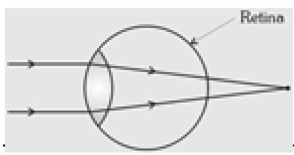
(1) Distant object are not seen clearly But nearer object are clearly visible
(2) Image formed before retina



(3) Far points come closer
(4) Reasons
(a) Focal length or radii of curvature

Hypermetropia (long sightness)

(1) Distant object are seen clearly but nearer object are not clearly visible.
(2) Image formed behind the retina



(3) near points moves away.
(4) Reasons
(a) Focal length or radii of curvature

Of lens reduced

(5) Removal : By using a concave of suitable focal length

(6) f= $\frac{xy}{x-y}$

of lens increases.

(5) Removal : By using a convex lens lens

(6) f = $\frac{d\,D}{d-D}$

Astigmatism : In this defect eye cannot see horizontal and vertical lines clearly; simultaneously . It is due to imperfect spherical nature of eye lens. This defect can be removed by using cyclindrical lens. (torric lenses)

Simple microscope : It is a single convex lens of lesser focal length also called magnifying glass or reading lens.

Magnification's when final image is formed at D and α (ie m_D and m_α) $m_D = [\, 1 + \frac{D}{f} \,]_{max}$

And $m_\alpha = [\, \frac{D}{f} \,]_{min}$

If lens is kept at a distance from the eye then $m_D = [\, 1 + \frac{D-a}{f} \,]$ and $m_\alpha = [\, \frac{D-a}{f} \,]$

Compound microscope : It consists of two converging lenses called objective and eye lens. $f_{eye\ lens} > f_{objective\ lens}$

$(\text{Diameter})_{eye\ lens} > (\text{diameter})_{objective\ lens}$

Final image is magnified, virtual and inverted

Magnification $m_D = -\frac{v_0}{\mu_0}\left(1 + \frac{D}{fe}\right) = \frac{-f_0}{(\mu_0 - f_0)}\left(1 + \frac{D}{fe}\right) = \frac{v_0 - f_0}{f_0}\left(1 + \frac{D}{fe}\right)$

$$m_\alpha = -\frac{v_0}{\mu_0}\left(\frac{D}{fe}\right) = \frac{-f_0}{(\mu_0 - f_0)}\left(\frac{D}{fe}\right) = \frac{v_0 - f_0}{f_0}\left(\frac{D}{fe}\right)$$

where μ_0 = distance of objective (o)

V_0 = Distance of image (n'B') formed by objective from objective.

μ_e = Distance of A' B' from eye lens.

V_e = Distance of final image from eye lens

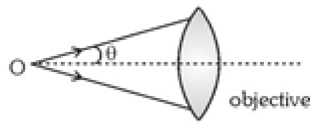
f_0= focal length of objective

f_e = focal length of eye lens.

- For maximum magnification both f_0 and f_e must be less.

$m = m_{objective} \times m_{eye\ lens}$

Resolving limit and resolving power : In reference to a microscope the minimum distance between two lines at which they are just distinct is called resolving limit (RL) and it's reciprocal is called Resolving Power (RP).



R. L = $\frac{\lambda}{2\mu\, sin\theta}$

R. P = $\frac{2\mu\, sin\theta}{\lambda}$ ⇒ R. P. α $\frac{1}{\lambda}$

μ sin θ = Numerical aperture

λ = wave length of light

μ = refractive index of the medium,

θ = half angle of the cone of the light from the point object.

Telescope : By telescope distant object are seen.

(a) Astronomical telescope :

(1) Used to see heavenly bodies.
(2) $f_{objective} > f_{eye\ lens}$ and $d_{objective} > d_{eye\ lens}$
(3) Intermediate image is real, inverted and small.
(4) Final image is virtual , inverted and small

Magnification $m_D = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$ and $m_\alpha = -\frac{f_0}{f_e}$

Length of tube = $L_D = f_0 + \mu_e = f_0 + \frac{fe\ D}{fe + D}$ and $L_\alpha = f_0 + fe$

(b) Terrestrial telescope :

(1) Used to see far of object on the earth
(2) It consists of three converging lens – objective, eye lens and erecting lens.
(3) Its final image virtual, erect & smaller.

$m_D = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$, $m_\alpha = -\frac{f_0}{f_e}$,

$L_D = f_0 + 4f + 2\mu = f_0 + 4f + \frac{f\ D}{fe + D}$

$L = f_0 + 4f + f_e$

(c) **Galilean telescope :** It is also a terrestrial telescope but of much smaller field view. Objective lens is a converging lens while eye lens diverging

$m_D = \frac{f_0}{f_e}\left(1 - \frac{f_e}{D}\right)$ and $m_\alpha = -\frac{f_0}{f_e}$

ONE WORD QUESTIONS

1. Focal length of a plane mirror is _______ _______
2. A ray of light incidents on a plane mirror at an angle of 30 ^{0} the deviation produced in the ray is ____________
3. A man of length h requires a mirror to see this own complete image of length at least equal to ___________
4. A man runs to wards mirror at a speed of 15m/ sec. What is the special of his image _____________
5. Mirage is a phenomenon due to ______________
6. The unit of focal power of lens is ___________
7. Blue colour of sky is due to the phenomenon of ____________sunlight.
8. Astigmatism can be corrected by using __________lens
9. An air bubbles in water behaves as _________lens.
10. The first element discovered in the sun is ____________
11. If the angle of prism is 30 ^{0} that rays incident at 600 and deviation produced is 30^0 then the angle of emergence is ____________
12. Relation between critical angle and refractive index is _____________
13. An endoscope is employed by a physician to view the internal parts of a body organ. It is based on the principle of _________.
14. A white screen illuminated by green and red lights appears to be _______colour.
15. Two thin lenses of power + 6 D and -2 D are in contact . What is the focal length of the combination ?

TRUE OR FALSE QUESTIONS

1) Velocity of light is constant in all media ________ T/ F
2) The virtual image formed in a plane mirror can be photographed.______ T/F
3) A real, inverted same sized image can be formed using a convex mirror. __ T/F
4) Brilliance of Diamond is due to total internal reflection __________ T/ F
5) Finger prints are observed by the use of microscope ________ T/F
6) The focal length of the objective lens of a compound microscope is greater than the focal length of eye piece. __________ T/F
7) In optical fibers the refractive index of the core is greater than that of cladding _______ T/F
8) The critical angle of light passing from glass to air is minimum for violet colour ________ T/F
9) Compound microscope final image is magnified, virtual and inverted _________ T/F
10) Sunglasses, (goggles) have curved surface but they do not have any power _________ T/F

11) The fluorescent tube is considered better than an electric bulb why because efficiency of fluorescent. _____ T/F
12) The colour of the green flower seen through red glass appears to be dark. ___________ T/F
13) Own can move freely during night time, why because they have large number of rods on their retina ____________ T/F
14) If a plane glass slab is placed on the letters of different co lours of all the letters appear to be raised up to the same height. ___________ T/F
15) The resolving power of a telescope is more, if the diameter of objective lens is more ____________ T/ F

MATCH THE FOLLOWING

1. Match the Column I and Column II

	Column I	Column II
a)	An object is placed at focus before a convex mirror	(1) magnification is – α
b)	An object is placed at centre of curvature Before a concave mirror	(2) magnification is 0.5
c)	An object is placed at focus Before a concave mirror	(3) magnification is + 1
d)	An object is placed at centre of curvature Before a convex mirror	(4) magnification is -1

A. a – 2, b – 3, c – 4, d - 5 B. a – 5, b – 4, c – 3, d - 1

C a - 2, b - 4, c - 1, d - 5 D. a – 3, b – 5, c – 2, d- 4

2. Match the column -I and column -II

	Column – I	Column – II
a)	Mirage	(1) Refraction of light
b)	Apparent depth of object is Lesser than the actual depth in water	(2) scattering of sunlight
c)	Blue colour of sky	(3) total internal reflection
d)	The formation of rainbow	(4) dispersion of sunlight

A. a – 2, b – 3, c – 4, d-1 B. a – 3, b – 4, c-1, d-2

C.a – 4, b -1, c- 2, d – 3 D. a – 3, b – 1, c- 2, d- 4

3. **Match the column I and column II**

Column – I	Column – II
a) Lens of power + 2. 0 D	1) conversions of focal length 200 cms
b) Lens of combination of power + 0.25 D and + 0.25D	2) concave lens of focal length 40 cm
c) Lens of power – 2. 0 D	3) convex lens of focal length 50 cm
d) Lens combination of power - 60 D and 3.5 D -	4) concave lens of focal length 50 cm

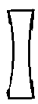
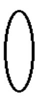
a) a - 1, b – 2, c – 3, d – 4 b) a – 3, b – 1, c - 4, d - 2
c) a - 4, b – 3, c – 1, d - 2 d) a - 3, b – 4, c – 2, d – 1

4.For an object placed in front of a mirror magnification (m) is given in column -I, column – II gives the possible nature of the mirror or that of image match appropriately.

Column – I	Column – II
a) $m = \frac{1}{4}$	1) concave mirror
b) m = - 1	2) convex mirror
c) m = 2	3) plane mirror
d) m = 1	4) Real

a) a – 2, b – 1, c – 4, d – 3 b) a – 1, b – 2, c – 4, d – 2
c)a – 2, b – 4, c – 1, d – 3 d) a – 1, b – 4, c – 3, d – 2

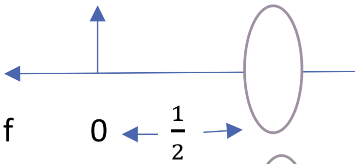
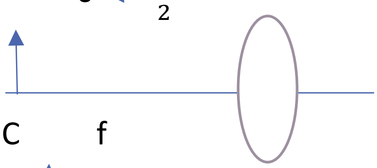
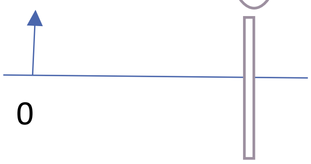
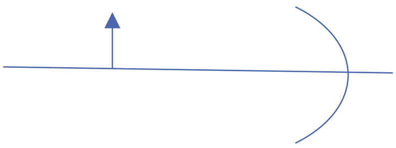
5) Match the column I and column II

Column – I	Column – II
a) 	1) plano convex
b) 	2) Bio concave
c) 	3) convexo concave
d) 	4) Bioconvex

(a)a - 3, b – 1, c – 2, d – 4 (b) a – 2, b – 3, c – 4 , d – 1

(c) a - 2, b - 4, c - 3, d - 1 (d) a – 3, b – 2, c – 1, d - 4

6. Match the following column II gives nature of image formed in various cases given in column – I

Column – I	**Column – II**
a) 	1) Real
b) 	2) Inverted
C) 	3) virtual
d) 	4) upright
	5) magnifical

(a)a → 1,2,3 , b → 4, 5 , c → 2, d → 1, 5

(b) a → 3, 4, 5, b→ 1, 2, 5, c→ 3, 4 , d→3, 4, 5

(c) a →1, b → 2, 3 , c → 4, 5, d → 1

(d) a →4, b → 3, 4, c → 2, 3 , d → 1

7. Match the following column I gives substances (transparent media with respect air) and column – II give refractive index.

Column – I	**Column – II**
a) Water	1) 2.42
b) Diamond	2) 1. 33
c) Crown glass	3) 1. 52
d) Dense flint glass	4) 1.62

(a) a - 2, b - 1, c - 1, d - 2 (b) a - 2, b - 1, c – 3, d – 4

(c) a - 1, b - 2, c - 3, d - 4 (d) a - 3, b – 4, c – 1, d – 2

8. Match the Column – I and column – II

Column – I	Column – II
a) Terrestrial telescope	1) final image is inverted
b) Galileo's telescope	2) no chromatic aberration
c) Reflected telescope	3) final image is erected
d) Astronomical telescope	4) use concave lens for eye piece to obtain erected image.

(a) a - 3, b – 2, c – 4, d – 1 (b) a - 1, b- 4, c - 3, d – 2

(c) a - 3, b - 4, c – 2 d - 1 (d) a -2, b - 1, c – 2, d – 3

MULTIPLE CHOICE QUESTIONS

1. Electro magnetic radiation belonging to ________region of spectrum is called light .
   (a) 100nm to 400 nm b) 400 nm to 750 nm
   (c)750 nm to 1000nm d) 1000 nm to 1400 nm

2. A plane mirror reflects a pencil of light to form a real image then the pencil of light incident on the mirror is

(a) parallel b) convergent c) divergent d) none of the above.

3. A plane mirror produces a magnification of

(a) -1 b) + 1 c) 0 d) between 0 and ∝

4. A watch shows time as 3.25 when seen through a mirror time appeared will be

(a) 8 : 35 b) 9 : 35 c) 7 : 35 d) 8 : 25

5. A light bulb is placed between two plane mirrors inclined at an angle of 60 0. The number of images formed are

(a) 6 b) 2 c) 5 d) 4

6. A man having height 6m. He observes image of 2m height erect then mirror used is

(a) concave (b) convex (c) plane (d) none of these

7. If an observer is walking away from the plane mirror with 6m/sec. The velocity of image with respect to observer will be _______

(a) 6m / sec (b) – 6m/sec (c) 12 m /sec (d) 3m /sec

8. An object is placed 40 cm from a concave mirror of focal length 20 cm. The image formed is

(a) Real inverted & same size (b) Real, inverted, same size

(c)Virtual, erect & langer (d) virtual, erect & smaller.

9. In vacuum the speed of light depends upon

(a) frequency (b) wave length (c) velocity of the source of light

(d) none of these.

10. Stars are twinkling due to

(a) diffraction (b) reflection (c) refraction (d) scattering

11. An astronaut in a spaceship see the outer space as

(a) white (b) black (c) blue (d) red

12. The reason of seeing the sun a little before the sunrise is

(a) reflection of light (b) refraction of the light

(c) scattering of the light (d) dispersion of the light

13. When a light wave goes from air to in to water the quality that remains unchanged is its

(a) speed (b) amplitude (c) frequency (d) wave length

14. The index of refraction of diamond is 2.0 velocity of light in diamond in cm/sec is approximately.

(a) 6×10^{10} (b) 3×10^{10} (c) 2×10^{10} (d) 1.5×10^{10}

15. The refractive index of a certain glass is 1.5 for light whose wave length in vacuum is 6000 AA. The wave length of this light when it passes through glass is

(a) 4000 AA (b) 6000 AA (c) 9000 AA (d) 1500 AA

16. The critical angle of light passing from glass to air is minimum for

(a) red (b) green (c) yellow (d) violet

17. If the critical angle for total internal reflection from a medium to vacuum is 30 0, the velocity of light in the medium is

(a) 3×10^{8} m /sec (b) 1.5×10^{8} m /sec (c) 6×10^{8} m /sec (d) $\sqrt{3} \times 10^{8}$ m/sec

18. The phenomenon utilised in an optical fiber is

(a) refraction (b) interference (c) polarization (d) total internal reflection

19. Relation between critical angle of water an glass is

(a) $C_w > Cg$ (b) $C_w < Cg$ (c) $C_w = Cg$ (d) $C_w = Cg = 0$

20. The reason for shining of air bubble in water is

(a) diffraction of light (b) dispersion of light (c) scattering of light

(d) total internal reflection of light

21. A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of combination is

(a) -1.5D (b) – 6.5 D (c) + 6.5 D (d) + 6. 67D

22. A double convex thin lens made of glass (refractive index μ = 1.5 has both radii of curvature of magnitude 20 cm incident light rays parallel to the axis of the lens wil converge at a distance L such that

(a) L = 20 cm (b) L = 10 cm (c) L = 40 cm (d) L = $\frac{20}{3}$ cms

23. Two thin lens of focal lengths f1 and f2 are in contact and coaxial. The combination is equivalent to a single lens of power

(a) $f_1 + f_2$ (b) $\frac{f_1 f_2}{f_1+f_2}$ (c) $\frac{1}{2}$ (f1 + f2) (d) $\frac{f_1+ f_2}{f_1 f_2}$

24. Least distance of distinct vision is 25 cms. Magnifying power of simple microscope of focal length 5 cm is

(a) $\frac{1}{5}$ (b) 5 (c) $\frac{1}{6}$ (d) 6

25. In a compound microscope the intermediate image is

(a) virtual , erect and magnified

(b) real, erect and magnified

(c)real, inverted and magnified

(d) virtual , erect and reduced.

26. The angular magnification of a simple microscope can be increased by increasing

(a) focal length of lens (b) size of object

(c) aperture of lens (d) power of lens

27. If F_0 and F_e are the focal length of the objective and eye piece respectively of a telescope then its magnifying power will be

(a)F0 + Fe (b) F0 x Fe (c) $\frac{F_0}{F_e}$ (d) $\frac{1}{2}$(F_0 + F_e)

28. The focal lengths of the objective and eye lenses of a telescope are respectively 200 cms and 5 cm. The maximum magnifying power of the telescope will be

(a) + 40 (b) – 48 (c) – 60 (d) 100

29. For a telescope to have large resolving power the

(a) focal length of its objective should be large

(b) focal length of its eye piece should be large

(c)focal length of its eye piece should be small

(d) aperture of its objective should be large.

30. Identify the mismatch in the following

(a) myopia _________ concave lens

(b) for rear view ____________concave mirror

(c)hyper motropia __________convex mirror

(d) astigmatism __________cylindrical lens.

ONE WORD QUESTIONS

1) Infinite 2) 120 ^{0} 3) $\frac{h}{2}$ 4) 15m/ sec (5) total internal reflection

(6) diopter (7) scattering (8) cyclindrical lens (9) concave lens

10) Helium (11) zero (12) $\mu = \frac{1}{\sin i\, c}$

(13) Total internal reflection (14) Yellow (15) + 4 D

TRUE OR FALSE QUESTIONS

1) False (2) true (3) false (4) true (5) true (6) false

(7) true (8) true (9) true (10) true (11) true (12) true

(13) true (14) false (15) true

MATCH THE FOLLOWING QUESTIONS

1) C	2. D	3. B	4. A
5) B	6. B	7. B.	8. C

MULTIPLE CHOICE QUESTIONS

1. B	2. B	3. B	4. A	5. C	6. B	7. C
8. A	9. D	10 C	11. B	12. B	13. C	14. D
15. A	16. D	17. B	18. D	19. A	20. D	21. A
22. A	23. D	24. D	25. C	26. D	27. C	28.
29. D						

PROBLEMS (LEVEL – 1)

1. Two vertical plane mirrors are inclined at an angle of 600 with each other. A ray of light travelling horizontally is reflected first from one mirror and then from the other the resultant deviation ?

   Ans. 240^{0}

2. A ray of light incident on the first mirror parallel to the second and is reflected from the second mirror parallel to first mirror. Find the angle between the two mirrors ? Ans. $\theta = 60^{0}$
3. An object 5 cm tall is placed 1m from a concave spherical mirror which has a radius of curvature of 20 cm. The size of the image is ?

   Ans : - 0.55 cm

4. Velocity of light in glass whose refractive index with respect to air is 1.5 is 2×10^{8} m/sec and in certain liquid the velocity of light found to be 2.5×10^{8} m/sec. The refractive index of the liquid with respect to air is ?

   Ans : 1.2

5. The wave length of light in two liquids x and y is 3500 A 0 and 7000 A0. Then the critical angle of x relatively to y will be ?

   Ans : 30^{0}

6. A convex lens of focal length 40 cm is an contact with a concave lens of focal length 200 m . Find the power of the combination ?

   Ans : P = -1.5D

7. The distance between an object and the screen is 100 cm. A lens produced an image on the screen when placed at sighter of the position 40 cm apart. Find the power of the lens ?

Ans $P \cong 5$ D

8. A ray of light passes through an equilateral glass prism in such a manner that the angle of incidence is equal to the angle of emergence and each of these angles is equal to ¾ of the angle of the prisms. Find the angle of deviation is ?

Ans : $\delta = 30^{0}$

9. Flint glass prism is joined by a crown glass prism to produce dispersion without deviation. The refractive indices of these for mean ray are 1.602 and 1.500 respectively. Angle of prism of flint is 10^{0}. Calculate the angle of prism for crown prism ?

Ans : $A = (12.04)^{0}$

$A = 12^{0}\ 41'$

10. The focal lengths of the objective and eye lens of a microscope are 1 cm and 5 cm respectively. If the magnifying power for the replaced eye is 45 . Find the length of the tube ?

Ans : $L_{\alpha} = 15$ cm

11. A compound microscope has a magnifying power 30. The focal length of its eye piece is 5 cm. Assuming the final image to be at the least distance of distinct vision. Calculate the magnification produced by the objective ?

Ans : $m_0 = -5$

12. The diameter of the eye-ball of a normal eye is about 2.5cm . The power of the eye lens varies from ?

Ans : 44 D to 40 D

PROBLEMS (LEVEL – 2)

1. A ray reflected successively from two plane mirrors inclined at a certain angle undergoes a deviation of $300^{.0}$. The number of images observable are ?

   Ans : 11
2. An object of length 2.5 cm is placed at a distance of 1.5 f from a concave mirror where f is the magnitude of the focal length of the mirror. The length of the object is perpendicular to the principle axis. Find the length of the image.

   Ans : -5 cm
3. A square of side 3 cm is placed at a distance of 25 cm from a concave mirror of focal length 10 cm. The center of the square is at the axis of the mirror and the plane is normal to the axis. Find the area enclosed by the image of the wire ?

   Ans : 4 cm^2.
4. A ray of light is incident at the glass – water interface at angle i, it emerges finally parallel to the surface of water. Find the value of μ_g ?

   Ans : $\mu_g = \frac{1}{\sin i}$
5. The power of a thin convex lens (a^{ug} = 1.5) is + 5.0 when it is placed in a liquid of refractive index of a ug, then it behaves a concave lens of focal length 100 cm. Find the refractive index of liquid a u1.

   Ans : $a^{\mu 1} = \frac{5}{3}$

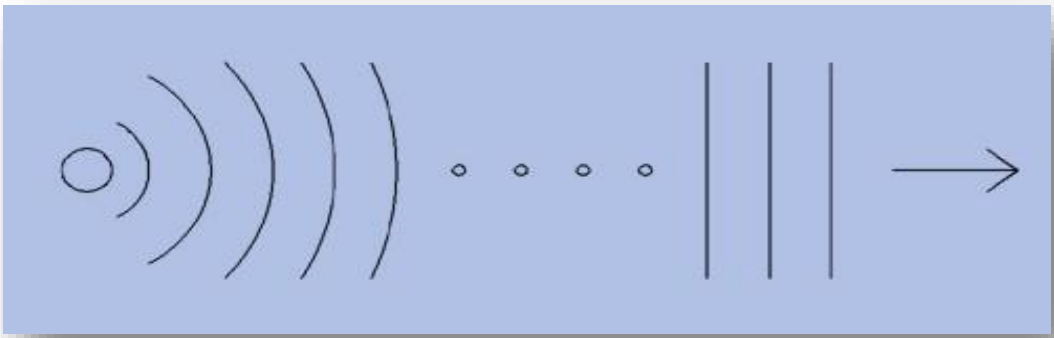
3. Wave Optics

Synopsis

Wavefront:-A locus of points, which oscillate in phase, is called a wavefront or it can also be defined as a surface of constant phase.

A point source emits spherical waves where as at large distances from the source, a small portion of a spherical wave can be approximated by a plane wave.

Whereas wavefront emitted by a narrow slit is cylindrical in shape.



Huygens' Principle: - All points on wave front serve as point sources of spherical secondary wavelets.

Actually a part of the wave enters into a telescope, but it forms complete image of the object.

The laws of reflection and refraction can be explained with the help of this principle.

Doppler Effect: - Change in the frequency of light due to the relative motion of the source and the observer.

When the light source moves away from the observer, its wavelength shifts to the red end of the spectrum (Red shift) and when the light source moves towards the observer, its wavelength decreases towards blue end of the spectrum (Blue shift).

The gravitational red shift gives conclusive evidence that the universe is expanding.

$\frac{\Delta u}{u} = \frac{v_{radial}}{c}$ (OR) $\frac{\Delta \lambda}{\lambda} = \frac{\quad}{c}$ (when source is moving away)

principle of superposition:-At a particular point in the medium, the resultant displacement produced by a number of waves is the vector sum of the displacements produced by each of the waves

$$Y = y_1 + y_2 + y_3 + \ldots\ldots\ldots\ldots$$

Resultant amplitude two superimposing waves: -

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\theta}$$

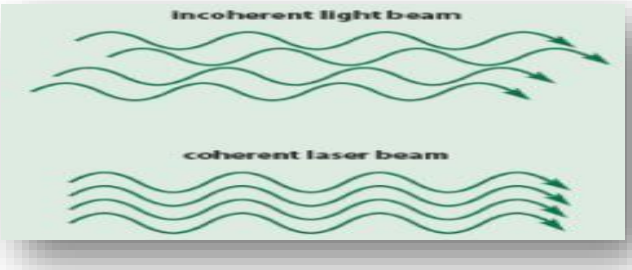
The resultant intensity due to two coherent sources is given by the equation

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$$

$$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

Coherent waves: - light waves which are in phase or with constant phase difference are called coherent waves.



Interference: - when two or more coherent waves combine, they either enhance or suppress certain colours in the spectrum.

Example: colours of soap bubbles, colours of butterflies etc.

intensity at a point: if two sources are coherent with constant phase difference Φ then the resultant intensity is given by $I=4I_0 \cos^2(\frac{\phi}{2})$

The relation between path difference (x) and phase difference (ϕ) is $\phi = \frac{2\pi}{\lambda}(x)$

Note :-

However if two sources do not maintain a constant phase difference then there is no interference pattern. Then the resultant intensity is simply $2I_0$. This is indeed what happens when two separate light sources illuminate a wall.

Condition

for constructive interference: - if we have two coherent sources S_1 and S_2 vibrating in phase, then at any point P the path difference,

$$S_1P \sim S_2P = n\lambda \quad (n=0, 1, 2, 3, \ldots)$$

$$d \sin\theta = n\lambda$$

$$\theta = n\lambda/d$$

or position of the n^{th} bright fringe is $x_n = n\frac{\lambda D}{d}$

and the resultant intensity will be $I=4I_0$

Condition for destructive interference:- if the path difference between S_1P and S_2P is

$$S_1P \sim S_2P = (n+\frac{1}{2})\lambda \quad (n=1,2,3,\ldots)$$

Similarly position of n^{th} dark fringe is $x_n = (n+\frac{1}{2})\frac{D}{d}$

Then the resultant intensity is $I=0$

Fringe width of interference fringes- Young's double slit experiment

$$\beta = \frac{\lambda D}{d}$$

here λ is wavelength of light used

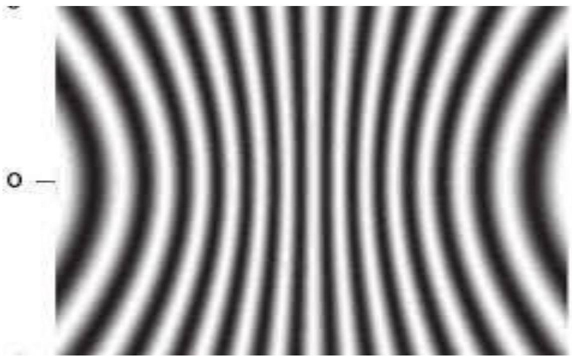
D is the distance from slits to the screen

d is the distance between two slits

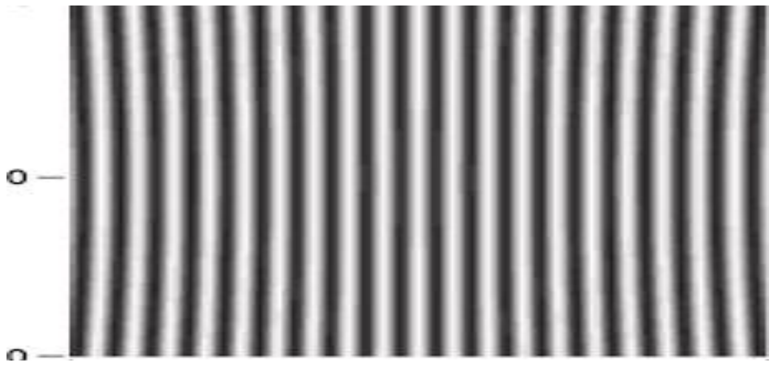
Interference fringes are hyperbolic in nature but if the distance D is large then the fringes will be nearly straight lines.

Importance of young's double slit experiment: first time it showed the evidence of wave nature of light.

Fringes are straight lines although S_1 and S_2 are point sources. If we had slits instead of point sources then the fringes are straight lines with increased intensities.



(When D is small)



(When D is large)

An operation in young's double slit experiment:-

Operation	Effect
1. Screen is moved away from slits	Angular separation **(**λ**/**d) remains constant but the actual separation of the fringes increases.
2. When a source is replaced by another source of shorter wavelength.	The separation of fringes and also angular separation decreases.
3. Separation between two slits is increased.	The separation of fringes and also angular separation decreases.
4. When the source slit is moved towards the double slit plane	Interference pattern gets less and less sharp and finally disappear.
5. The monochromatic source is replaced by a white light.	White fringe at the centre with red fringes on either side of it and the blue at the farthest.

Diffraction: - It is defined as the bending of waves around the corners of an obstacle or through an aperture into the region of its geometrical shadow.

Diffraction is a general characteristic exhibited by all types of waves like sound waves, water waves or even matter waves.

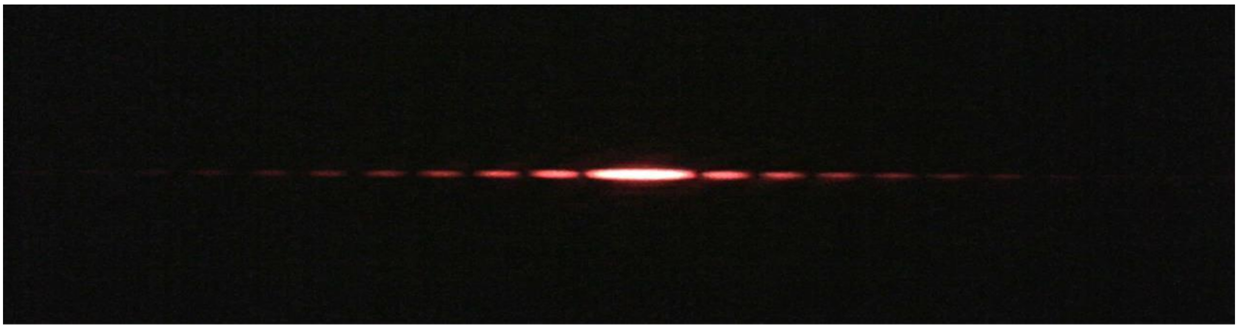
Diffraction of light can be observed when the wavelength of light is comparable to the size of the object (a**≈**λ**)**

- The finite resolution of our eye or optical instruments such as microscope or telescope is limited due to the phenomenon of diffraction and also the objects appear blurred due to diffraction.
- In a single slit diffraction experiment, dark fringes are produced where the path difference
  (a sinθ= mλ) between the top and bottom rays of a slit are equal to λ,2λ,3λ,…….

For minima- dark fringes $a\sin\theta = m\lambda$ for m=1, 2, 3….

(or) $\theta = \frac{m\lambda}{a}$

For maxima-bright fringe $\theta = (m + \frac{1}{2})\frac{\lambda}{a}$



(Figure: Diffraction pattern of a single slit)

Comparison between interference and diffraction patterns:-

Interference	Diffraction
1.Interference pattern has a number of equally spaced bright and dark bands	**1. The diffraction pattern has a central bright maximum. On either side away from the central maxima intensity of maxima falls**
2.The interference pattern is formed by superposing waves from two narrow slits	**2. Diffraction pattern is a superposition of continuous family of waves originating from each point from the single slit.**
3. We get maximum at an angle θ= λ/a for two narrow slits separated by a distance "a".	**3. For same angle θ=λ/a we get minimum intensity for a single slit of width "a".**

- **In interference and diffraction, light energy is redistributed. If it reduces in one region producing a dark fringe, it increases in another region, producing a bright fringe. That means energy is conserved both in interference and diffraction.**

Resolving power of optical instruments:- **The ability of an optical instrument or an eye to separate two closely spaced objects.**

Rayleigh's criteria for resolving power is $\sin\theta = 1.22\frac{\lambda}{a}$

we can separate two closely spaced objects like stars if their angular separation θ is small. That can be achieved by small wavelength of light used and by using large aperture of objective lens.

The resolving power of human eye= $\frac{d}{D}$

Here d is the separation between two objects and D is the distance from the object to our eye.

The resolving power of the compound microscope $= \frac{2n \sin Q}{1.22\lambda}$ **where n is the refractive index of the medium between the object and objective.**

The product nsinβ is called the numerical aperture marked on the objective.

The validity of ray optics:-

light behaves like rays only up to certain distance called Fresnel distance (Z_F). Beyond that it spreads like a wave.

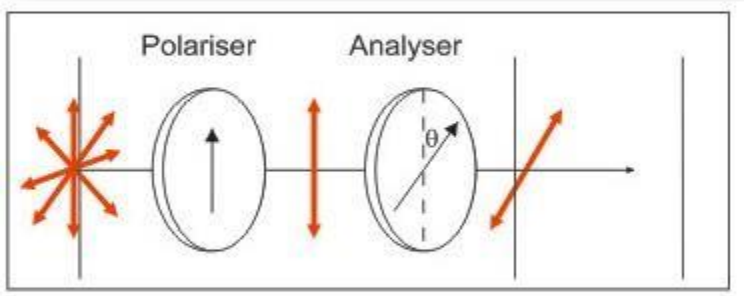
Fresnel distance $Z_F = a^2/\lambda$

here a is the width of the beam or size of the aperture.

Polarization:-

Natural light that we receive from the sun is unpolarised. This means the electric vector is in all possible directions in transverse plane. When this unpolarised light is passed through certain crystals like tourmaline, topaz, and calcite then the vibrations are limited to one plane only. That light is called linearly polarized or plane polarized. Polarized light can be obtained by transmission, reflection, refraction and by scattering.

We need pair of Polaroids to tell whether the light is polarized or not.



Malus' law: - The intensity of plane polarized light that passes through an analyzer varies as the square of the cosine of the angle between the polarizer and the analyzer axes.

$$I = I_0 \cos^2\theta$$

Brewster's angle: - It is the angle at which the reflected light is completely plane polarized.

$$i_B = \tan^{-1}(\mu)$$

Short answer questions

1. What is Huygens' principle?. What is its advantage?

2. What is the principle of superposition of waves?
3. What is the relation between path difference(x) and phase difference (Φ) of a light wave.
4. What are coherent light sources? Give an example for such sources.
5. What is red shift and blue shift of wavelengths
6. What is meant by monochromatic light? Is white light a monochromatic light?
7. Can two tube lights produce interference pattern? Explain.
8. What is interference? Give an example for interference of light in our daily life.
9. What is diffraction? Give condition for diffraction of light to occur.
10. Why a camera with large aperture can produce high clarity photos than a camera with small aperture?
11. What is polarization? Is the light directly coming from the sun a polarized light?
12. Define malus' law.

13. What is polarizing angle or Brewster's angle?
14. What are the uses of Polaroids?

Fill up the blanks

1. Laser beam is coherent because it contain coherent waves of__________(all/single) wavelength.
2. When exposed to sunlight thin film of oil on water exhibit brilliant colours due to the phenomenon of________________.
3. When a star is moving away from us, its colour shifts to__________(Red/Blue) end of the spectrum.
4. When light enters from rarer medium to denser medium, its frequency_______(changes/constant).
5. When white light is used in young's double slit experiment______colour is immediately on either side of the central white fringe.
6. If the distance between the slits and the screen is not large in young's experiment, the fringe pattern is_______________(hyperbolic/ straight lines).
7. Only_____________(coherent/monochromatic) light waves can produce interference.
8. _________________(Dark shadow/Bright spot) appears at the circular object's due to diffraction.
9. The intensity of bright fringes____________(increases/decreases) as we move away from the central bright fringe.
10. We can increase the resolving power of the telescope by___________(increasing/decreasing) the wavelength of light and by____________(increasing/decreasing) the aperture of the objective.
11. The resolving power of the compound microscope is____________(directly/inversely) proportional to the wavelength of light used.
12. Light waves can be polarized as they are_______________(longitudinal/ Transverse) in nature.
13. At the_____________angle reflected light is completely plane polarized.
14. Polaroids are used in sunglasses, as they can decrease the intensity of incident light by___________ (half/ quarter)
15. At Brewster's angle, the angle between reflected and refracted rays is_______________.

(Key :(1). Single 2. Interference 3). Red 4) Constant 5) Red 6) Hyperbolic 7) Coherent 8) Bright spot 9) Decreases 10) Decreasing, increasing 11) inversely 12) Transverse 13) Polarizing angle or Brewster's angle 14) Half 15) 90°

True or False

1. While teacher is writing on the board, we can listen his voice but we can't see his face because sound waves can diffract where as light waves can't diffract over his face due to their short wavelengths. (T/F)
2. If the slit is made narrower and narrower, when the size of the slit is comparable with wavelength of light, then it is collimated into a fine beam. (T/F)
3. Flying birds and aero planes don't cast their shadows on the earth due to diffraction of light. (T/F)
4. The resolving power of an Eagle eye is more than human eye due to the large diameter of a pupil of an Eagle's eye and less diffraction effects in it. (T/F)
5. From Huygens' wave construction we came to know that when a partial wave front enters into a telescope it forms incomplete or partial images. (T/F)
6. When white light is used in young's double slit experiment, the colour adjacent to the central bright fringe is red since it is destructive interference for the violet colour at that place. (T/F)

7. The coloured wings of Morpho butterfly is not due to the colour pigment, but due to interference of light by the lines present on its wings. (T/F)

8. Honey bees, ants and various other creatures use the direction of polarization of light in the sky as an aid to navigation. (T/F)
9. Electron microscope is used to see the finer details of the insects as its resolving power is superior to that of optical microscope due to small wavelengths of electrons. (T/F)
10. Polaroid films in photography are still in use even in the digital era. As we need not wait long period for their development and printing, moreover they can't be tampered or manipulated. can be used for the security purpose. (T/F)

(Answers key: 1) T 2)F 3) T 4) T 5) F 6)T 7)T 8) T 9) T 10) T

Match the following

1. Match the wave fronts with their sources

I	II
1) a point source	a) Cylindrical wave front
2) The portion of the wave front of light from distant star	b) Spherical wave front
3) when light comes from a horizontal slit	c) Plane wave front
4) Light emerging out of convex lens when source is at its focus	d) None

(Answers:- 1-b, 2-c, 3-a, 4-c)

2. Match the path differences with their corresponding phase differences

I	II
1) 0	a) π
2) λ	b) 3π
3) $\lambda/2$	c) 0
4) $3\lambda/2$	d) 2π

(Answers:- 1-c, 2-d, 3-a, 4-b)

3. Match the following processes with their phenomenon

I	II
1) superposition of two coherent waves	a) Diffraction
2) superposition of infinite waves from a single slit	b) Resolving power
3) The ability of an optical instrument or an eye to separate closely spaced objects like stars	c) Polarization
4) Restricting vibrations of light into one plane	d) Interference

(Answer: 1-d, 2-a, 3-b, 4-c)

4. Match the following with their formulae.

I	II
1) Brewster's angle	a) $Z_F = a^2/\lambda$
2) Malus' law	b) **sin**θ**=1.22** $\frac{\lambda}{a}$
3) Fresnel distance	c) $\tan^{-1}(\mu)$
4) Resolving power of Telescope	d) $I = I_0 \cos^2\theta$

(Ans:- 1-c , 2-d, 3-a , 4-b)

5. Match the terms with their corresponding values in young's double slit experiment.

I	II
1) Fringe width	a) $n\frac{\lambda D}{d}$
2) Intensity of central bright fringe	b) $\beta=\frac{\lambda D}{d}$
3) Location of n^{th} maxima	c) $(n-\frac{1}{2})\frac{\lambda D}{d}$
4) Location of n^{th} minima	d) $4I_0$

(Ans:- 1-b, 2-d ,3-a, 4-c)

6. Match the following terms with their corresponding values in single slit diffraction.

I	II
1) Condition for diffraction at single slit	a) $(m+\frac{1}{2})\frac{\lambda}{a}$
2) Location of m^{th} minima	b) $2\frac{\lambda}{a}$
3) Location of m^{th} maxima	c) $a \sim \lambda$
4) width of central maximum	d) $m\frac{\lambda}{a}$

(Ans :- 1-c, 2-d, 3-a, 4-b)

Multiple choice questions

1. The phenomenon which is not explained by Huygens' construction ( )
   a) Reflection b) Refraction
   c) Diffraction d) Origin of spectra
2. Two coherent monochromatic light beams of intensities I and 4I superimpose. The maximum and minimum possible intensities in the beam are ( )
   a) 5I and I b) 5I and 3I
   c) 3I and I d) 9I and I

3. A narrow slit of width 1mm is illuminated by monochromatic light of wavelength 600nm.The distance between the first minima on either side of a screen at a distance of 2m is ( )

   a) 1.2cm   b) 1.2mm
   c) 2.4cm   d) 2.4mm

4. If two sources are having randomly varying phase difference Φ,the resultant intensity will be given by ( )

   a) $\sqrt{2}\, I_0$ b) $I_0/2$
   c) $2I_0$ d) zero

5. What happens if monochromatic light used in young's double slit experiment is replaced by white light. ( )

   a) No fringes observed
   b) All bright fringes become white
   c) All bright fringes have colours between violet and red
   d) only the central fringe is white and all other fringes are coloured

6. A double slit experiment is carried out in air and the entire arrangement is dipped in water. Then the fringe width ( )

   a) Increases   b) decreases
   c) Remains unchanged   d) Fringe pattern disappear

7. In young's double slit experiment, the slit separation is made 3 fold. The fringe width becomes ( )

   a) 1/3 times   b) 1/9 times
   c) 3 times   d) 9 times

8. The light of wavelength λ is incident on a slit of width a, then condition for diffraction is

   a) a/λ=1   b) a/λ>>1 ( )
   c) a/λ<<1   d) none

9. What is the angle of diffraction for the first minimum with a source of wavelength 550nm is incident on a slit of width 0.55mm ( )

   a) 0.001 rad   b) 0.01 rad
   c) 1 rad   d) 0.1 rad

10. A slit of size a is placed at a distance D from the screen. On illuminated it by a light of wavelength λ. The width of central maxima will be. ( )

   a) $\frac{2\lambda D}{a}$ b) $\frac{\lambda D}{a}$
   c) $\frac{3\lambda D}{a}$ d) $\frac{\lambda a}{D}$

11. In young's double slit experiment intensity at appoint is (1/4) of the maximum intensity angular position of this point is

   a) $\sin^{-1}(\frac{\lambda}{d})$ b) $\sin^{-1}(\frac{}{2d})$ ( )
   c) $\sin^{-1}(\frac{}{3d})$ d) $\sin^{-1}(\frac{\lambda}{4d})$

12. The polarizing angle for a medium is 60°. What will be the critical angle for that media?

   a) $\sin^{-1}\sqrt{3}$ b) $\tan^{-1}\sqrt{3}$ ( )
   c) $\cos^{-1}\sqrt{3}$ d) $\sin^{-1}(1/\sqrt{3})$

13. A Polaroid is placed at 45° to an incoming light of intensity I_0. Now the intensity of light is passing through Polaroid after polarization would be ( )

a) I_0 b) $I_0/2$

c) $I_0/4$ d) Zero

14. Plane polarized light is passed through a Polaroid on viewing through the the Polaroid we find that when the Polaroid is given one complete rotation about the direction of light, one of the following is observed ( )

a) Intensity of light gradually decreased to zero and remains at zero

b) Intensity of light gradually increased to maximum and remains at maximum

c) There is no change in intensity

d) Intensity of light is twice maximum and twice zero

15. Estimate the distance for which ray optics is good approximation for an aperture of 4mm and wavelength 400nm ( )

a) 40m b) 40cm

c) 40mm d) 400nm

16. In young's double slit experiment the intensity is I at appoint where the path difference is $\lambda/6$. If I_0 denotes the maximum intensity then I/I_0 ( )

a) $\sqrt{3}/2$ b) 1/2

c) ¾ d) $1/\sqrt{2}$

17. The angular resolution of 10cm diameter telescope at wavelength of 5000A° is of the order of

a) 10^6rad b) 10^{-2}rad ( )

c) 10^{-4} rad d) 10^{-6} rad

18. Two Polaroid sheets are kept at 90° with each other. Now a third Polaroid is kept with an angle θ with the first Polaroid. Then what is the intensity of transmitted light through all of them

a) $I = (I_0/4)\sin^2 2\theta$ b) $I = (I_0/4)\cos^2 2\theta$ ( )

c) $I = (I_0/4)\sin^2\theta$ d) $I = (I_0/4)\cos^2\theta$

19. Four light waves are represented by

i) $y = a\sin\omega t$ ii) $a\sin(\omega t+\Phi)$ iii) $y = a\sin 2\omega t$. iv) $y = a\sin 2(\omega t+\Phi)$

interference fringes may be observed due to the superposition of ( )

a) i and ii b) i and iii

c) ii and iv d) iii and iv

20. **Let s be the size of the source and S its distance from the plane of two slits. For interference to be seen, the condition to be satisfied is** ( )

a) $s/S \le \lambda/d$ **b)** $s/S \ge \lambda/d$

c) $S/s \le \lambda/d$ d) $S/s \ge \lambda/d$

Answers:- 1.(d), 2(d), 3(d), 4(c), 5(d), 6(b), 7(a), 8(a), 9(a), 10(a), 11(C), 12(d), 13(c), 14(d), 15(a) 16(c), 17(d), 18(a), 19(d), 20(a).

Problems (Level 1)

1. **The wavelength of yellow sodium light in air is 5890A°.When it enters into glass of refractive index 1.5, what is its (a) wavelength b) frequency c) velocity in glass**
2. The observed wavelength of light coming from a distant galaxy is found to be increased by 0.5% as compared with that from a terrestrial source. The velocity of recession of that galaxy is
(Ans: 1.5×10^6m/s)
3. A monochromatic green light of wavelength 5×10^{-7}m, illuminates a pair of slits 1mm apart. Then the separation of bright lines on the interference pattern formed on a screen 2m away is
(Ans: 1mm)
4. A double slit experiment is performed with sodium light of wavelength 5893A° and the interference pattern is observed on a screen 100cm away. The 9^{th} bright fringe is at a distance 10mm from the central maximum. Find the separation between the two slits **(0.53mm)**
5. The light of wavelength 6328A° is incident on a slit of width 0.2mm perpendicularly, then the angular width of central maxima will be **(0.36°)**
6. A slit of width **a** is illuminated by white light. For what values of **a**, the first minimum of red light of wavelength 6500nm is at 30°. **(Ans: 1.3μm)**
7. An analyzer is inclined to the polarizer at an angle of 30°.The intensity of light emerging from the analyzer is $\frac{1}{n}$ th of that incident of the polarizer, then the value of n is **(Ans: 8/3)**
8. What is the Brewster angle for air to glass transition (μ_g=1.5) **(Ans. 56.31°)**

Problems (Level 2)

1. In a young's double slit experiment 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600nm is used. If wavelength of light is is changed to 400nm, number of fringes observed in the same segment of the screen is
(Ans:18)
2. Maximum intensity in young's double slit experiment is I_0. Find the intensity at appoint on the screen where
   a) The path difference between two interfering beams is π/3 (Ans: (a) $\frac{3}{4}I_0$
   b) The path difference between them is λ/4 **(b) $I_0/2$**
3. In a young's double slit experiment, slits are separated by 0.5mm away. A beam of light consisting of two wavelengths 650nm and 520 nm, is used to obtain interference fringes on the screen. The least distance from the common central maximum to the point where the bright fringes due to the both the wavelengths coincide is **(Ans: 7.8mm)**
4. In a double-slit experiment the angular width of the fringe is found to be 0.2° on a screen placed 1m away. The wavelength of light used is 600nm. What will be the angular width of the fringe if the entire apparatus is immersed in water of refractive index 4/3. **(Ans: 0.15°)**
5. What is the minimum angular separation between two stars if a telescope is used to observewith an objective of circular aperture 20cm? The wavelength of light used is 5900A° **(3.6×10^{-6} rad)**

*********The End*******

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ELECTRIC CHARGES & FIELDS

SYNOPSIS

INTRODUCTION :

ELECTRICITY : Is a branch of physics in which the electric charges are studied is known as electricity.

Sub branches of Electricity are (a) Electrostatics (b) Electro dynamics.

Electrostatics - study the charge at rest.

Electrodynamics - Study of the charges are in motion.

ELECTRIC CHARGE :

- Electric charge is a basic property of matter, due to which it is able to produce as well as experience in electric and magnetic effects.
- Electric charge is a scalar quantity.

SI unit in 'C' is Coloumbs

Dimensional Formulae : $[M^0 L^0 T^1 A^1]$ (or) [TA]

- There are two basic charges

Charge

+ve positive | - Negative (-ve)

- Body looses electrons . It is said to acquire charge
- Mass of the body decreases when it is positively charged

* body gains electrons , it the is said to acquire - ve charge.
* Mass of the body increases when it is - vely charged.

- Like signed charges repel each other. Unlike signed charges attract each other.

- No charge & an inhibited system remains curtail.

3)Properties of Charge

(a)Charge is conserved

(b)Charge is quantized.

(c)Charge obeys additive property.

4. Methods of charging : **(i)** By Friction

(ii) Conduction

(iii) Induction.

5. There are two basis type of materials.

(i) Conductors : Materials such as metals, but allow the free movement charges.

(ii) Inductors : Materials such as rubber and glass, but don't allow the free movement of charges.

Coulomb's Inverse Square Law :

Statement : The force of attraction (or) repulsion between two stationary point charges q_1 & q_2 which are separated by a distance 'r' in air (or) vaccum is given by

$$F_{vaccum} = \boxed{\frac{1}{4\pi \mathrm{g}_0} \cdot \frac{q_1\ q_2}{\gamma^2}}\ \mathrm{N}$$

$\in_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$

$$\frac{1}{4\pi \mathrm{g}_0} = 9 \times 10^{9}\ N\ m^2\ c^{-2}$$

In vector form :

$$\boxed{F = \frac{1}{4\pi \mathrm{g}_0} \frac{q_1\ q_2}{\gamma^2}\ \gamma_N}\ \mathrm{N}$$

In medium :

$$\boxed{F_{medium} = \frac{1}{4\pi\epsilon_0} \frac{q_1\ q_2}{\gamma^2}}\ \mathrm{N}$$

'K' is the dielectric constant (or) relative permitivity.

$$K = \epsilon_{r} = \frac{\epsilon}{\epsilon_0}$$

Vaccum (or) air = K = 1

all insulating material K > 1

all conductor K = α

Columbus electro static force is ________Conservative
________Central
_________Independent presence of the other charges.

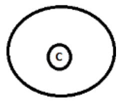
7. Force between multiple charges :

According to principle of super position

$$\vec{F} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \cdots \ldots \ldots \vec{F}_{17}$$

8. Electric field :

Def : Be region of space around an electric charge in which its effect can be experienced is known as electric field.



Uniform Electric Field :

Both direction & Magnitude is same everywhere in the field.

Non-uniform Electric field :

If either the magnitude (or) direction (or) both change in the field.

Intensity & the electric field :

Def : The force experienced by a unit positive charge placed at that point.

$$\vec{F} = \vec{E}q_0 \quad \therefore \quad \vec{F} = \frac{\vec{F}}{q_0}$$

- Intensity of Electric field in a vector quantity.
- If q_0 is + ve →(Force acting on it is in the direction of the field).

  -ve → (Force is opposite to direction of the field)
- SI unit $\frac{N}{C}$ (newton/coloumb) (or) $\frac{v}{m}$ (volt/meter)
- Dimensional Force $[M^{1} L^{1} T^{-3} A^{-1}]$

9) Electric lines of force :

(i) The electric lines of force starts from +ve charge and on a -ve (negative) charge.

(ii) The tangent drawn at any point on the line of the force gives directions of electric field.

(iii) No two lines of force intersect each other. Be reason is that if they do so then at the point of intersection two tangents can be drawn in two directions of force are possible which is impossible.

(iv) The lines of force perpendicular to equipotential surfaces.

Electric Flux :

Def : The number of lines of force emerging out a closed surface is called electric flux.

9 $_b$ = E. A

9 $_b$ = E. A cos θ

- Scalar quantity
- V. m Nm^2/C

Electric Dipole :

Def : The arrangement of two equal and opposite point charges at a four distance is called an electric dipole.

Dipole moment $\vec{p}$ = q x 2l

Direction of $\vec{p}$ is from – q to + q

Electric field due to a dipole :

(i) At any point on the axis of the dipole

$$E = \frac{1}{4\pi g_0} \frac{2\,l}{\gamma^2} \text{ N/C}$$

[Direction of $\vec{E}$ is parallel to the dipole moment $\vec{P}$]

(ii) At any point on the director plane of the dipole.

$$E = \frac{1}{4\pi g_0} \frac{P}{\gamma^2} \text{ N/C}$$

[Direction of $\vec{E}$ is anti parallel to the dipole moment $\vec{P}$]

- Couple acts on a electric dipole in uniform electric field.
  - It experiences only torque ➚ = PE sin θ
    ➚ = P x E
  - Not force on the dipole is zero.
  - ➚ = 0 when it aligns itself parallel to the electric field.
  - ➚ = maximum is T max = PE sin 900

T_{max} = PE

If E = 1 N/C $\boxed{T_{max} = P}$

The potential energy of dipole in an electric field.

U = - PE cos θ

Inverse form U = - $\underset{p}{\rightarrow} . \underset{E}{\rightarrow}$

The work due w = PE (cos θ_1 = cos θ_2)

If $\theta_1 = 0^0$, $\theta_2 = 90^0$ w = PE

If $\theta_1 = 0^0$, $\theta_2 = 180^0$ w =2 PE

- Continuous charge distribution :

  Linear charge density λ = $\frac{d\,q}{d\,l}$

  Surface charge density σ = $\frac{d\,q}{ds}$

  Volume charge density P = C

- **Gauss Law in electric statics :**

  Statement **:** The total flux linked with a closed surface in 1/ E0 times is not charged enclosed by the closed surface.

  $$\oint E\,ds = \frac{q}{g_0}$$

  Applications :

  (1) Electric field due to infinitely long straight charged wire :

  $$E = \frac{\lambda}{2\,\pi g_0 \gamma}$$

  (2) Electric field due to a infinite plane sheet of charge.

  $$E = \frac{\sigma}{2\,g_0}$$

(3) Electric field due to a charged hollen sphere :

(a) Outside of the sphere :

$E_{out} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$

$E_{out} = \frac{\sigma R^2}{\epsilon_0 r^2}$

(b) At the surface of the sphere :

$E_s = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$

$E_s = \frac{\sigma}{\epsilon_0}$

(c)Inside of the sphere

$E_{in} = 0$

VERY SHORT ANSWER QUESTIONS

1)What happens to the weight of a bod when it is charged positively ?

2)The electric lines of force never intersect each other . Why ?

3)Write the expression for electric intensity due to an infinite plane sheet & charge.

4)When is the electric flux negative and when is it positive ?

5)Repulsion is the sure test of charging than attraction . Why ?

6)How many electrons consitute 1 C of charge ?

7)When does the maximum torque acts on the dipole is kept in uniform electric field

8)Can we calculate the intensity of the electric field due to a dipole by Gauss Law in electrostatics ?

9) Write down an expression in vector form for the potential energy of the electric dipole is kept in uniform electric field.

10) Why the electric field at the outer surface of a hollow charged conductor is normal to the surface ?

11) Can a solid conducting sphere hold more charge than a hollow sphere of the same radius ? Give reason.

TRUE / FALSE

(1) When a body gains electron, it is said to acquire positive charge, when a negative charge given to a body then its mass decreases . (T/F)

(2) Law of Conservation of Charge is applicable to all stationary & moving charges. (T/F)

(3) A body can be charged by friction and conduction only cannot by induction. (T/F)

(4) Charge given to a conductor always resides on its outer surface (T/F)

(5)Force between two point charges is dependent of presence of other charges

(T/F)

(6)Coulomb's electric static force is a non-conservative force (T/ F)

(7)If q0 is positive, then the direction of the force is in the direction of the field . (T/F)

(8) The electric lines of force diverge from positive charge and converge to negative charge. (T/F)

(9) If the lines of force are concided then the field is strong. (T/F)

(10)Electric lines of force will be parallel to the surface of conductor. (T/F)

(11) In uniform electric field, the lines of force are straight is parallel to one another (T/F)

(12) Charge is always in the form of an integral multiple of electron charge and never its function . (T/F)

(13) If a charge 'q' is placed in a charged shell, it does not experience any force due to shell . (T/F)

FILL IN THE BLANKS :

(1) The Gaussian surface for sphere (or) spherical shell is ___________
(2) Induction always precedes _____________
(3) Force between two point charges is________of presence of other charge.
(4) ___________electric field exists between the parallel plates of capacitor.
(5) The tangent at any point to the line of fore gives the________of the field at that point.
(6) Intensity of the electric field inside the conducting charged sphere is _________
(7) The direction of a dipole movement from___________to___________.
(8) When the dipole is placed in the uniform electric fields not force acting on the dipole is ____________
(9) Two identical metallic spheres of exactly equal masses are taken. One is given a positive charge 'q' C, and H the other an equal negative charge 'q' C. Are their masses are equal after charging ________

(10) Electric lines of force are always_______________to an equi potential force.

(11) The electric field at a point on equation of line of a dipole and direction of dipole movement will be in opposite direction.

(12) e law, governors the force between electric charges is known as

(13) A neutral body gets positive charge by___________and gets negative charge by__.

MATCH THE FOLLOWING

(1)

1. Flux	(a) N c^{-1}
2. Permitivity	(b) c – m
3. Intensity of the electric field	(c) N – m^2 c^{-1}
4. dipole moment	(d) N – m^2 /C^2

(2)

1. volume charge density	(a) $[L' T' A']$
2. Flux	(b) $[M' L' T^{-3} A^{-1}]$
3. Dipole moment	(c) $[L^{-3} T' A']$
4. Intensity of electric field	(d) $[M' L^{3} T^{-3} A^{-1}]$

(3) Intensity of the electric field

1. Axis of the dipole	(a) $ɤ^{-1}$
2. Infinite long straight conductor	(b) $ɤ^{-2}$
3. outside of the sphere of radius R	(c) $p\,ɤ^{-3}$
4. Bisector plane of the dipole	(d) $2\,p\,ɤ^{-3}$

(4)

1. Outside of the charger sphere	(a) $\frac{\sigma}{g_0}$
2. Inner region of the parallel plate capacitor	(b) $\frac{\sigma}{2g_0}$
3. Infinite long charged wire	(c) $\frac{q}{4\pi g_0 ɤ^2}$
4. Infinite charged plane	(d) $\frac{\lambda}{2\pi g_0 ɤ^2}$

(5)

1. If ‘q’ be the centre of the cube	(a) $\frac{q}{6\epsilon_0}$
2. From each face of cube	(b) $\frac{q}{g_0}$
3. ‘q’ is one of its corner	(c) $\frac{q}{24 g_0}$
4. ‘q’ is placed at one of its vertices	(d) $\frac{q}{8g_0}$

(6)

1. If positive charge enclosed	(a) net flux result to zero.
2. If negative charge enclosed	(b) net flux outward
3. If a dipole is enclosed	(c)net flux inward
4. If a charge is enclosed	(d) net flux is equal to charge enclosed by surface)

(7)

(1) electron	(a) 1.674×10^{-27} kg, zero C
(2) proton	(b) 9.1×10^{-31} kg , + 1.6×10^{-19} C
(3) neutron	(c) 1.673×10^{-27} kg , + 1.6×10^{-19} C
(4) Anti particle of electron	(d) 9.1×10^{-31} kg, - 1.6×10^{-19} C

(8)

(1) e^-	(a) Ruther ford
(2) P^+	(b) J. J. Thomson
(3) O'n	(c)Anderson
(4) e^+	(d)Chadwick.

(1) If $\theta_1 = 0^0$, $\theta_2 = 90^0$	(a) E = 0
(2) $\vec{T}_{max} = \vec{P}$	(b) w = 2PE
(3) Electric field due to charged shall at infinity	(c)E = 1
(4)If $\theta_1 = 0^0$, $\theta_2 = 180^0$	(d) w = PE

MULTIPLE CHOICE QUESTIONS
LEVEL – 1

1) Due to the motion of a charge, its magnitude
   (a) Increases (b) decrease (c) depends on its speed (d) No charge

2) The Coulomb Electric static force is defined for
(a) Two spherical charges at rest.
(b) Two spherical charges in motion.
(c) Two point charges in motion
(d) Two point charges at rest.

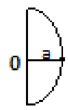
3) The wrong statement about electric lines of force is
   (a) These are originate from positive charge and end at –ve charge.
   (b) They don't intersect each other at a point.
   (c) They have the same form for each point charge and a sphere.
   (d) They have physical existence.

4) A point charge is kept at the centre of a metallic insulated spherical shell than
   (a) Electric field outside the sphere is zero .
   (b) Electric field inside the sphere is zero.
   (c) Not induced charge on the sphere is zero.
   (d) Electric potential inside the sphere is zero

5) Two small spheres each carrying a charge ‘q’ are placed ‘r’ metre apart. If one of the spheres is taken around the other one in a circular path of radius ‘r’. The work done will be equal to
   (a) Force between x ɤ
   (b) Force between them x 2**π** ɤ
   (c) Force between / 2**π** ɤ
   (d) Zero

6) The small balls having equal positive charge ‘q’ on each are suspended by two insulating string of equal lengths 1m from a hook fixed to a stand. The whole is taken in a satellite into space, where Isomere is no gravity, what is ISE angle between the strings.
   a)45^0 b) 60^0 c) 90^0 d) 180^0

7) Electric field at centre ‘o’ semi circle radius ‘a’ having linear charge density are given by



a) $\frac{2\lambda}{g_0 a}$ b) $\frac{\lambda\pi}{g_0 a}$ c) $\frac{\lambda}{2\pi g_0 a}$ d) $\frac{\lambda}{\pi g_0 a}$

8) An electric dipole of moment ‘P’ are lying along a uniform electric field ‘E’. Then work done in rotating the dipole by 900 is
   a) PE b) PE c) $\frac{PE}{2}$ d) 2PE

9) A charge ‘q’ is enclosed by a Guassion surface of radius ‘R’. If the radius is doubled, then the outward flux will be
   a) Increase ‘4 ‘ times b) be redued to half
   c)remain the same d) be doubled

10) A dipole & dipole moment ‘P’is placed in uniform electric field. Then torque acting on a given way

a) $\vec{T} = \vec{P} \cdot \vec{E}$ b) $\vec{T} = \vec{P} \times \vec{E}$ c) $\vec{T} = \vec{P} + \vec{E}$ d) $\vec{T} = \vec{P} \cdot \vec{E}$

11) The electric force between the metal plates of an isolated plate capacitor ‘C’ having a charge ‘q’ and area ‘A’ is

a)Independent of the distance between the plates.

b)Linearly proportional to distance between the plates.

c)Proportional to square root of the distance between the plates.

d)Inversely proportional to the distance of the plates.

12) Dielectric constant of water is 80, what is its permitivity ?

a)4 b) 5 c) 7 d) 9

13) The magnitude of electric intensity at a distance ‘x’ from charge ‘q’ in ‘E’. An identical charge is placed at a distance ‘2x’ from it. Then the magnitude of the force it experiences in

a)Eq b) 2 Eq c) $\frac{Eq}{2}$ d) $\frac{Eq}{4}$

14) An electric dipole kept in a uniform electric field experiences

a)A force and a torque b) a force but not a torque

c)A torque but not a force d) neither force nor a torque

15) The value of electric potential at any point due to any electric dipole is

a) $K \frac{\vec{p} \cdot \vec{r}}{r^2}$ b) $K \frac{\vec{p} \times \vec{r}}{r^3}$ c) $K \frac{\vec{p} \cdot \vec{r}}{r^2}$ d) $K \frac{\vec{p} \cdot \vec{r}}{r^2}$

16) An electric dipole is placed at an angle of 300 to a non-uniform electric field. The dipole will experience

a) a translational force only in the direction of the field

b) a translational force only in a direction of the field

c) a torque as well as a translational force

d) a torque only

17) If E a be the electric field strength of a short dipole at a point on it axialline and Ee that on the equitorial line at the same distance, then

(a) E_e - 2 Ea b) E_a = 2Ee c) E_a = E_e d) Plane of a surface

18) The magnitude of the electric field on the surface of a sphere of radius or having a uniform surface charge density ' σ '.

a) $\frac{\sigma}{g_0}$ b) $\frac{\sigma}{2g_0}$ c) $\frac{\sigma}{g_0 \gamma}$ d) $\frac{\sigma}{2g_0 \gamma}$

19) If the electric flux entering and learning an enclosed surface respectively is , the electric charge in side the surface and the

a)(q_2 – q_1) ϵ_0 b) (q_1 + q_2) ϵ_0 c) (q2 – q1) d) (q1 +)

20) Find the vector quantities

1) Intensity of the electric field 2) electric flux

2) Electric dipole moment 4)electric charge

21) Two electrons separated by distance 'r' experienced a force 'F' between them. The force between a proton and a singly ionized helium atom separated by distance '2 r' is

A) F/2 b) 2F c) F/4 d) 4F

22) Two point charges placed at a distance 'r' in the air experiences a certain force, then the distance at which they will experience the same force in the medium & dielectric const 'K'

A) Rk b)

23) A charge oil drop is suspended in uniform field of 3 x 10 4 v/m. so that it neither falls nor rises of the charge on the drop will be (take mass of the charge = 9.9 x 10 -15 kg, g = 10 m/s2)

(a) 3 x 10 -15 C b) 0.3 x 10 -15 C c) 3.3 x 10 -18 C

(e) 0.33 x 10 -18 C

24) The inward and outward flux of a closed surface in units of N - m2/c respectively 8 x 10 3 and 3 x 10 3 . The positive total charge inside the surface is SI units is

A) (12 x 10 3) E 0 b) 12E 0 c) 4 E0 d) (4 x 10 3) E0

25) A point charge placed at any point on the axis is an electric dipole at some large distance experiences a force 'F'. What will be the force acting on the positive charge when its distance from the dipole is doubled ?

A) 8 b F/8 c) F/16 d) 16 F 1

MULTIPLE CHOICE QUESTIONS :
LEVEL - 1

1) b	2) d	3) d	4) c	5) d
6) d	7) c	8) a	9) c	10) b
11)a	12) c	13) d	14) c	15) d
16) c	17)b	18) a	19)a	20)d
21) c	22) d	23) c	24) d	25) b

LEVEL - II

1) c	2) c	3)d	4)c	5)d	6)d
7) a	8)c	9) c	10) c	11)c	12)d
13)c	14)b	15)b			

MCQ - LEVEL - II

(1) $F = 9 \times 10^{9} \left(\frac{q^2}{r^2} \right) = q = 10^{-5}$ $ne = 10^{-5}$

$n = \frac{10^{-5}}{1.6 \times 10^{-19}}$

(2) W = F. S.

Match the following :

1. 1 - C	2 - D	3 - A	4 - B
2. 1 - C	2 - D	3 - A	4 - B
3. 1 - D	2 - A	3 - B	4 - C
4. 1 - C	2 - A	3 - D	4 - B
5. 1 - B	2 - A	3 - D	4 - C
6. 1 - B	2 - C	3 - A	4 - D
7. 1 - D	2 - C	3 - A	4 - B
8. 1 - B	2 - A	3 - D	4 - C
9. 1 - D	2 - C	3 - A	4 - B

TRUE / FALSE

1. F
2. T
3. F
4. T
5. F
6. F
7. T
8. T
9. T
10. F
11. T
12. T
13. T

KEYS FOR FILL IN THE BLANKS

(1) Concentric Sphere
(2) Attraction
(3) Independent
(4) Uniform
(5) Direction
(6) Zero
(7) -ve to + ve
(8) Zero
(9) No
(10) Perpendicular
(11) Opposite
(12) Coulomb's Law
(13) Losing electrons, gained by electrons.

*******THE END ********

ELECTROSTATIC POTENTIAL AND CAPACITANCE

Synopsis

What is electric potential?

Electric potential of a point in an electric field is the amount of work done in bringing a unit charge (without acceleration) from infinity to that point.

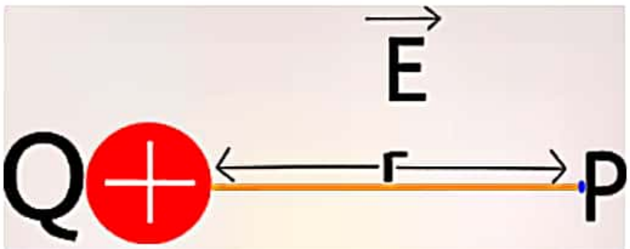
Many people sometimes don't understand this definition and don't get a clear idea about what an electric potential is and generally they get confused between **electric potential, electric potential energy** and **potential difference**.

All these three terms differ from each other but they are so closely related that you will eventually get confused and in order to understand the concept of **Electric Potential** fully with basics we need to learn these three terms differently to avoid confusion.

Electric Potential:

suppose a positive ***charge 'Q'*** is present and it creates an **electric field 'E'**. Inside the electric field there lies a point ***point 'P'*** and distance between **charge 'Q'** and **point 'P'** is **'r'**

Now in simpler terms due to this **charge 'Q'**, there will be some potential at a **point 'P'** which lies inside **electric field 'E'**



Charge Q creates potential at point P inside electric field

Symbol of electric potential is 'V' and the formula is:

$$Electric\ \ potential\ (V) = k.\frac{Q}{r}$$

Here **'k'** is a constant.

In the formula you can clearly see that **potential is directly proportional to the *charge 'Q'*** so ***more is the charge more will be the potential at the point 'P'***

Electric potential is the characteristic of a point present in electric field and many of you often relate electric potential with electric charge but it's not a characteristic of electric *charge.*

Electric potential is characteristic of a place in an electric field meaning that when you will put some charge at that particular spot the charge will have energy based on the **potential of that point.**

Electric potential energy:

Electric potential energy of ***charge 'q'*** at a point is the ***work done by external forces in bringing charge 'q' from infinity to that point present.***

Well, both these definition of electric potential energy and electric potential seems same, right? But there is little difference when we talk about electric potential energy and electric potential. ***In electric potential energy, we talk about work done by external force in bringing charge 'q' from infinity to point*** but when we are talking about the ***electric potential we are dealing with the work done by external force in bringing a unit charge 'q' from infinity to a point.***

So in case of electric potential energy, we deal with charge whereas in electric potential a unit charge is considered.

Potential difference:

We learned that electric potential is a characteristic of point present in the electric field and not a characteristic of electric charge. So at one point **potential is V_1** and at a different point **potential is V_2** then the difference between this potential **$V_2 - V_1$ will be your potential difference.**

Equipotential surface:

These ***are the surfaces where electric potential at every point is the same.***

How is it possible that potential is the same at all the points? Well, this is the formula of electric potential for a *single charge Q:*

$$Electric\ \ potential\ \ (V) = k.\frac{Q}{r}$$

So **electric potential 'V' will be constant** and the same for all the points if the **distance between the point and charge 'r' is constant.**

So ***equipotential surfaces*** of a single point charge present at the centre are ***concentric spherical surfaces.***

What is dielectric?

Dielectrics are non-conducting substances, in other words, we can also say that dielectric is just another name of the insulator. So, this ***dielectric has no or negligible charge carrier present inside*** them, therefore, they can't conduct.

What happens when a dielectric is introduced to an external electric field?

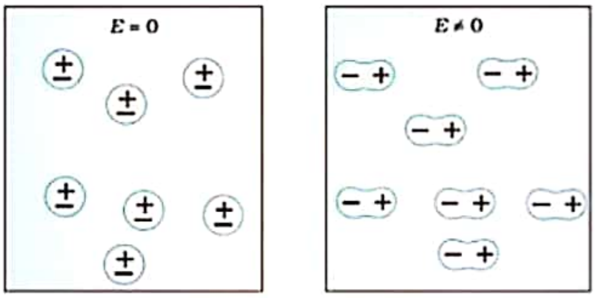
When a dielectric is introduced with an external electric field as they don't have charge carriers like a conductor when they are introduced in external electric field it has been seen that the ***electric field induces dipole moment by stretching or re-orienting molecules of a dielectric.***

The combined effect of all the dipole moment in dielectric creates a net electric field that opposes the external electric field but unlike conductor, this created opposing field does not completely cancel out but instead, it reduces the effect of an external electric field to some extent.

Types of dielectric:

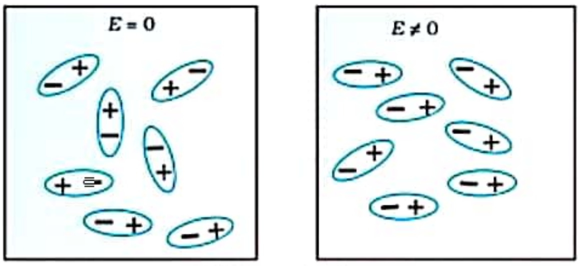
Dielectric is of two types ***(i) Non-polar and (ii) Polar***

Non-polar molecules: In this kind of molecules, *positive and negative charges are present at the centre* and they don't have distance between them, therefore, they don't have their own dipole. **For example, CO_2, H_2, and N_2.**



(a) Non-polar molecules

Polar molecules: In this, *positive and negative charge are not present at the centre and have some distance,* therefore they have dipole of their own. **For example, H_2O.**

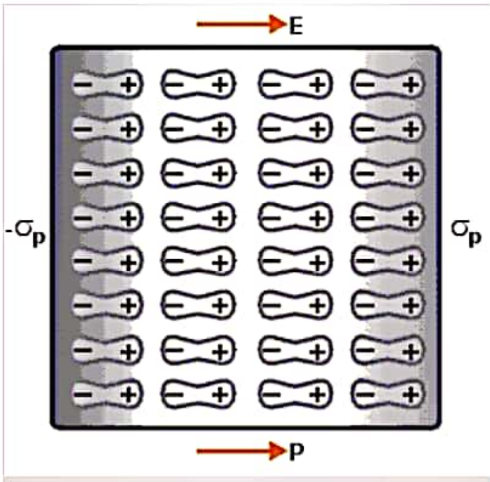


(b) Polar molecules

When *non-polar molecules are exposed to the external electric field they create a dipole moment but as soon as this external electric field is removed they get back to normal* whereas in case of polar molecules they have their own dipole moment but at molecular level net dipole moment in this dielectric is also 0 but due to different reason

What is polarisation?

Small dipoles or molecules arrange themselves according to the electric field. This is called polarisation.



A polarized dielectric

Capacitor:

A ***capacitor is the combination of two conductors separated by an insulator.*** This conductors have their own ***charges Q1 and Q2*** and due to this charge as we have discussed above they have ***electric potential V1 and V2*** as well.

In reality, these two conductors have charge ***+Q and -Q*** means opposite charges and a potential difference between these two conductors are **V= V1 - V2.**

Capacitance:

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We have seen that **electric potential 'V' is directly proportional to charge 'Q'** means when Q will increase the electric potential of the capacitor also increases.

So because they both are proportional to each other the ratio of Q and V is a constant:

$$C = \frac{Q(Charge)}{V(Potential)}$$

Formula of capacitance

This ***constant of the ratio of Q/V is called capacitance (C) of the capacitor***.

Capacitance 'C' does not depend on Q or V rather it depends on the geometry of capacitor such as shape, size and separation between a conductor in capacitors.

Capacitance is the ability of a capacitor to store electric charge in it.

Actually, the electric *charge in a capacitor is not stored in conductors 1 and 2 whereas it gets stored in an electric field present between the conductors.*

Standard Units of Capacitance

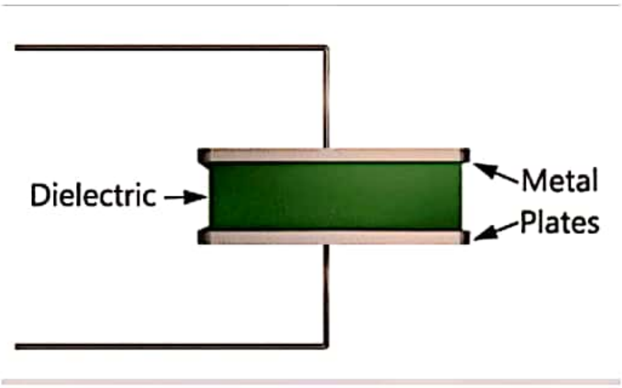
The basic unit of capacitance is Farad. But Farad is a large unit for practical tasks. Hence, capacitance is usually measured in the sub-units of Farads such as micro-farads (μF) or pico-farads (pF).

Most of the electrical and electronic applications are covered by the following standard unit (SI) prefixes for easy calculations:

- **1 mF (millifarad) = 10^{-3} F**
- **1 μF (microfarad) =10^{-6} F**
- **1 nF (nano-farad) = 10^{-9} F**
- **1 pF (picofarad) = 10^{-12} F**

Parallel plate capacitor:

The ***parallel plate capacitor consists of two large parallel conductor plates which are separated by a small distance.***



Parallel plate capacitor with a dielectric

The capacitance of a parallel plate capacitor is given by the formula $C=\epsilon_0 A/d$

Factors Affecting Capacitance

- Dielectric

The effect of dielectric on capacitance is that greater the permittivity of the dielectric the greater the capacitance, likewise lesser the permittivity of the dielectric the lesser is the capacitance. Some materials offer less opposition to the field flux for a given amount of field force. Materials with greater permittivity allow more field flux, hence greater charge is collected.

- Plate Spacing

The effect of spacing on the capacitance is that it is inversely proportional to the distance between the plates. Mathematically it is given as:

$C \propto 1/d$

- Area of the Plates

The effect of the area of the plate is that the capacitance is directly proportional to the area. Larger the plate area more is the capacitance value. Mathematically it is given as:
$C \propto A$

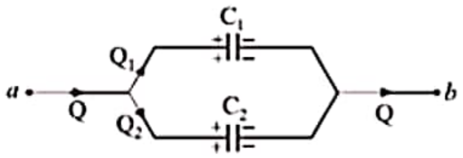
Energy Stored in a Capacitor

Once the opposite charges have been placed on either side of a parallel-plate capacitor, the charges can be used to do work by allowing them to move towards each other through a circuit. The total energy that can be extracted from a fully charged capacitor is given by the equation:

$U=1/2CV^2$

Parallel Combination of Capacitors

When capacitors are connected in parallel, the potential difference V across each is the same and the charge on C_1, C_2 is different i.e., Q_1 and Q_2.



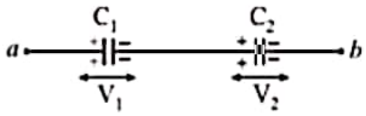
Equivalent capacitance between a and b is:

$C = C_1 + C_2$

In case of more than two capacitors, $C = C_1 + C_2 + C_3 + \ldots\ldots\ldots$

Series Combination of Capacitors

When capacitors are connected in series, the magnitude of charge Q on each capacitor is same. The potential difference across C_1 and C_2 is different i.e., V_1 and V_2.



$1/C = 1/C_1 + 1/C_2$

Or $C = C_1 C_2 / C_1 + C_2$

Important Points:

- If N identical capacitors of capacitance C are connected in series, then effective capacitance = C/N
- If N identical capacitors of capacitance C are connected in parallel, then effective capacitance = CN

5. Electrostatic potential and Capacitance

I. Very short Answer questions.

1. What is electrostatic potential?
2. What is an equipotential surface?
3. Why the potential of the earth is taken as zero?
4. When a charged conductor is placed near an earthed conductor, what happens to its potential and capacity?
5. Define polarisation.
6. Give an expression for the electrostatic potential energy of system of charges.
7. A comb run through one's dry hair attracts small bits of paper. Why?
8. An electric dipole of moment P is placed in a uniform electric field E, with P parallel to E. It is then rotated by an angle θ. Then what is the work done?
9. A 12 pF is connected to a 50V battery. How much electrostatic energy is stored in the capacitor?
10. What happens to the capacitance of a parallel plate capacitor if the area of its plates is doubled and the distance between the plates is halved?

II. Fill in the blanks.

1. The physical quantity in electrostatics analogous to temperature in heat is — Electric potential

2. Electric potential at the centre of a charged hollow metallic sphere is — Same as that on the surface.

3. Workdone in moving a positive charge on an equipotential surface is — ZERO.

4. A charged parallel plate capacitor has energy U. If the distance between the plates is doubled, its new energy is — doubled

5. A charge +Q is given to the positive plate and −Q to the negative plate of a capacitor. Then the charge on the capacitor is Q

6. If an electron is accelerated by a potential difference of 1 volt, it would gain an energy of 1.6×10^{-19} J

7. The unit of dielectric constant is no units

8. When three capacitors of capacitances 1 μF, 2 μF and 3 μF are connected in parallel, the ratio of charges is 1:2:3

9. A machine that can build up high voltages of the order of a few million volts is — Van de Graff generator

10. The expression for the energy density of electric field is $\frac{1}{2}\epsilon_0 E^2$

III. True / False statements.

1. A capacitor can store an infinite amount of charge (T/F)
False

2. The dielectric constant of perfect insulator is infinite. (T/F) False

3. Equal charges are given to two conducting spheres of different radii, then the potential will be more on smaller sphere. (T/F) True

4. The electric potential is uniform everywhere on the surface and inside a charged conductor. True

5. In case of a charged spherical conductor, the field inside is zero. (T/F) True

6. Inside a hollow spherical conductor, the potential is constant. (T/F) True

7. In space electric potential is zero, because electric field doesnot exist there. (T/F) False

8. Electrons in a conductor have no motion in the absence of a potential difference across it. (T/F) False

9. In polar dielectrics, each molecule has a permanent dipole moment but these are randomly oriented in the absence of an externally applied electric field. (T/F) True

10. Due to two opposite charges infinite number of zero potential points are formed. (T/F) True

IV. Match the following.

① List-I

a) Energy stored in capacitor
b) capacity of the capacitor
c) potential difference
d) Electric field

List-II

i) farad
ii) joule
iii) Volt/meter
iv) Volt

A) a→i, b→ii, c→iii, d→iv
B) a→iv, b→iii, c→ii, d→i
✓C) a→ii, b→i, c→iv, d→iii
c) a→ii, b→iii, c→iv, d→i

② List-I

a) joule
b) watt
c) volt
d) coulomb

List-II

i) Henry x amp/sec
ii) amp^2 x ohm
iii) coulomb x volt
iv) farad x volt

A) a→i, b→ii, c→iii, d→iv
B) a→iv, b→iii, c→ii, d→i
c) a→ii, b→i, c→iv, d→iii
✓D) a→iii, b→ii, c→i, d→iv

③ LIST-I

a) capacity of a conductor
b) capacity of a parallel plate capacitor
c) potential energy of a conductor
d) capacity of a spherical capacitor

LIST-II

i) $4\pi\epsilon_0 ab/(b-a)$
ii) Q/V
iii) $\epsilon_0 A/d$
iv) $\frac{1}{2}CV^2$

A) a→i, b→ii, c→iii, d→iv
B) a→iv, b→iii, c→ii, d→i
✓C) a→ii, b→iii, c→iv, d→i
D) a→ii, b→iii, c→i, d→iv

Multiple choice Questions

Level – I

1. Which of the following is equivalent to Volt?
   a) erg/cm b) N/coul-m^2 ✓c) joule/coulomb d) erg/ampere

2. A solid sphere and a hollow sphere of equal diameters are raised to the same potential. Then –
   ✓a) both have equal charge b) only hollow sphere has charge
   c) solid sphere has more charge d) hollow sphere has more charge.

3. If E is electric field, V is electric potential, then
   a) If $E=0$, V must be 0 b) If $V=0$, E must be 0
   c) If $E\neq0$, V cannot be 0 ✓d) None of these

4. Inside a charged hollow metallic sphere –
   a) $E=0, V=0$ b) $E\neq0, V\neq0$ c) $E\neq0, V=0$ ✓d) $E=0, V\neq0$

5. The capacitance of a capacitor doesnot depend upon
   a) Cross-sectional area of the plates b) separation between the plates
   ✓c) charge on the plates d) none of the above.

6. Putting a dielectric substance between the plates of a capacitor the capacity, potential and potential energy respectively –
   ✓a) increases, decreases, decreases b) decreases, increases, increases
   c) increases, increases, increases d) decreases, decreases, decreases

7. A liquid drop of 1 cm radius is given a charge of 1 μC. Then the potential at the surface of the drop is –
   a) 9×10^9 V b) 9×10^6 V ✓c) 9×10^5 V d) 9×10^3 V

8. The p.d. between the two parallel plates separated by a distance of 1cm is 100V. Then the intensity of the electric field between the plates is –
   a) 10^3 Vm^{-1} b) 10^4 Vm^{-1} ✓c) 10^5 Vm^{-1} d) 10^6 Vm^{-1}

(9) Consider a point charge 1.5×10^{-8} C. The radius of an equipotential surface having a potential of 30 Volts is —

a) 1.5 m b) 2.5 m c) 3.5 m ✓d) 4.5 m

(10) If n drops, each of capacitance C, coalesce to form a single big drop, then the capacitance of the big drop will be —

a) $n^3 C$ b) nC c) $n^{1/2} C$ ✓d) $n^{1/3} C$

(11) If the potential difference between the plates of a capacitor is increased by 20%, the energy stored in the capacitor increases by —

a) 20% b) 22% c) 40% ✓d) 44%

(12) Two conducting spheres of radii r_1 and r_2 have same electric field near their surfaces. Then the ratio of their electrical potentials is —

a) $\frac{r_1^2}{r_2^2}$ b) $\frac{r_2^2}{r_1^2}$ ✓c) $\frac{r_1}{r_2}$ d) $\frac{r_2}{r_1}$

(13) Variation in potential is maximum if one goes —

✓a) along the line of force b) perpendicular to the line of force

c) in any direction d) none of these

(14) At a point in space, the electric field points towards north. In the region surrounding this point, the rate of change of potential will be zero along —

a) north b) south c) North-south ✓d) East-west

(15) Which of the following is discontinuous across a charged conducting surface?

a) electric potential

✓b) electric intensity

c) Both electric potential and intensity

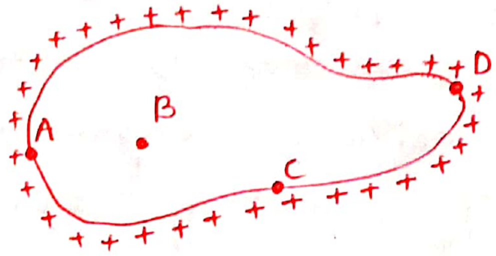
d) None of the above

Level – II

(1) Three charges $2q$, $-q$ and q are located at the vertices of an equilateral triangle. At the centre of the triangle –

a) the field is zero but potential is non-zero.
✓ b) the field is non-zero but potential is zero.
c) both field and potential are zero.
d) both field and potential are non-zero.

(2) For an isolated charged conductor shown in the figure, the potentials at points A, B, C and D are V_A, V_B, V_C and V_D respectively. Then –



a) $V_A = V_B > V_C > V_D$
b) $V_D > V_C > V_B = V_A$
c) $V_D > V_C > V_B > V_A$
✓ d) $V_D = V_C = V_B = V_A$

(3) A solid sphere of radius R is charged uniformly. At what distance from its ~~centre~~ surface is the electrostatic potential half of the potential at the centre?

a) R b) $\frac{R}{2}$ ✓ c) $\frac{R}{3}$ d) $2R$

(4) The electric field in a certain region is A/x^3. Then, the potential at a point (x,y,z) assuming the potential at infinity to be zero, is

a) zero ✓ b) $A/2x^2$ c) $3A/x^4$ d) A/x^2

(5) An electron having charge e and mass m starts from the lower plate of two metallic plates separated by a distance d. If potential difference between the plates is V, the time taken by the electron to reach the upper ~~plat~~ plate is —

✓ a) $\sqrt{\frac{2md^2}{eV}}$ b) $\sqrt{\frac{md^2}{eV}}$ c) $\sqrt{\frac{md^2}{2eV}}$ d) $\frac{2md^2}{eV}$

(6) Two metallic charged spheres of radii R_1 and R_2 having charges Q_1 and Q_2, respectively, are connected to each other. Then there is —

a) no change in the energy of the system
b) an increase in the energy of the system
c) always a decrease in the energy of the system
✓ d) a decrease in energy of the system unless $Q_1 R_2 = Q_2 R_1$

(7) Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel. What is the charge (in pC) on each capacitor if the combination is connected to a 100 V supply?

✓ a) 200, 300, 400   b) 300, 200, 400   c) 400, 300, 200   d) 400, 200, 300

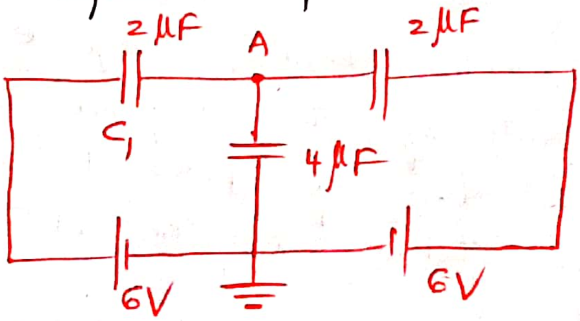
(8) To obtain a capacitance of 5 μF, by using some capacitors, each of 2 μF, the minimum number of capacitors required is —

a) 3   ✓ b) 4   c) 5   d) not possible

(9) Seven capacitors, each of capacitance 2 μF, are to be combined to obtain a capacitance of 10/11 μF. Which of the following combination is possible?

a) 2 in parallel, 5 in series
b) 3 in parallel, 4 in series
c) 4 in parallel, 3 in series
✓ d) 5 in parallel, 2 in series

(10) Three capacitors are connected as shown in the figure. Then, the charge on capacitor C_1 is —



✓ a) 6 μC
b) 12 μC
c) 18 μC
d) 24 μC

(11) A capacitor is charged to store an energy U. The charging battery is disconnected. An identical capacitor is now connected to the first capacitor in parallel. Then the energy in each of the capacitor is now —

a) $\frac{3U}{2}$ b) U ✓c) $\frac{U}{4}$ d) $\frac{U}{2}$

(12) A 2μF capacitor is charged to 100V and then its plates are connected by a conducting wire. Then the heat produced is —

a) 0.001J ✓b) 0.01J c) 0.1J d) 1J

(13) Ten capacitors are joined in parallel and charged with a battery up to a potential V. They are then disconnected from battery and joined in series. Then, the potential of this combination will be —

a) 1V ✓b) 10V c) 5V d) 2V

(14) A capacitor stores 50μC charge when connected across a battery. When the gap between the plates is filled with a dielectric, a charge of 100μC flows through the battery. Then the dielectric constant of the material is —

a) 1 b) 2 ✓c) 3 d) 4

(15) Three capacitors of capacitances 3μF, 9μF and 18μF are connected once in series and another time in parallel. Then the ratio of equivalent capacitances in the two cases will be —

✓a) 1:15 b) 15:1 c) 1:1 d) 1:3

CURRENT ELECTRICITY

Important Formulae:

1. Electric current $I = \frac{q}{t} = \frac{ne}{t}$ SI unit is Ampere.
2. Current density $j = \frac{I}{A}$ SI unit is Amp/m^2
3. Drift velocity $V_d = \frac{eE\grave{e}}{m}$, è = relaxation time
4. Mobility of electrons $\mu = \frac{Vd}{E} = \frac{eE}{m}$. SI unit m^2/vs
5. Relation between drift velocity and free electrons is $V_d = \frac{I}{Ane} = \frac{j}{ne}$
6. Ohm's law $V \alpha I$, V = RI where R is resistance measured in ohms
7. Resistivity or specific resistance $P = \frac{RA}{l}$; $P = \frac{m}{ne^2e}$
8. Conductivity $\sigma = \frac{1}{P}$
9. The resistivity of a metallic conductor is $P_T = P_0 [1 + \alpha CT - T_0]$, α is the temperature coefficient of resistivity
10. In series combination of resistors effective resistance

    $R = R_1 + R_2 + R_3$ $(V = V_1 + V_2 + V_3)$
11. In parallel combination of resistors $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $(I = I_1 + I_2 + I_3)$
12. Temperature dependence of resistance $R_t = R_o (1 + \alpha t)$
13. Emf of a cell $\varepsilon = V + I r$ where $I = \frac{E}{R+r}$ and r . $(\frac{\varepsilon}{V} -1)$ r R
14. Kirchoff's Rules : 1. Junction rule $\sum I = 0$

    2. Loop Rule $\sum V = 0$

15. Wheatstone Bridge balancing principle $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

16. Meter Bridge unknown resistance R = $\left(\frac{l_1}{100-l_1}\right)$ S where S is resistance in resistance box.

17. Potentio meter potential gradient $\phi = \frac{\in(l)}{l}$

18. Comparison of emfs of two cells using potentiometer is $\frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$

19. Internal resistance of a given cell using potentiometer is r. R $\left(\frac{l_1}{l_2} -1\right)$

Fill up the blanks :

1. When voltage V is applied across a conductor at a temperature T, the drift velocity of electrons is proportional to _____________.
2. The ratio of voltage and electric current in a closed circuit is ________.
3. Manganine wire is used for making standard resistance because it has ___________.
4. The name of the component which is designed to oppose the flow of current ____________.
5. The internal resistance of a cell is the resistance of __________used in cell.
6. If in the experiment of Wheat Stone's bridge, the positions of cell and galvanometer are interchanged the balancing point will _____________.
7. Kirchoff's second law shows that electrostatic force is a _________force.
8. In houses power of consumption is measured in kilowatt hours. 1 kilowatt hour = _____Jouls.
9. The magnitude of drift velocity per unit electric field is called _________.

10. The resistance of the wire is 121 Ω. It is divided into equal parts and they are connected in parallel, then effective resistance is 1Ω . The value of n is __________.
11. When potential difference is applied across an electrolyte, then Ohm's law is obeyed at _______potential.

12. A cell of internal resistance r drives current through an external resistance R, the power delivered by the cell to the external resistance will be maximum when __________.
13. Volt per ampere is called _________.

14. The amount of charge flowing per second per unit area normal to the flow is called ________.
15. Sensitivity of potentiometer can be increased by increasing ____________of potentiometer.

TRUE / FALSE QUESTIONS

1. Resistance of a metal decreases and that of a semi conductor increases with decrease in temperature.
2. Electric currents obey the law of vector addition.
3. In the absence of electric field drift velocity is zero.
4. When the resistances are connected parallel in a circuit the potential difference across them is constant.

5. The emf of a cell is equal to potential difference between its terminals when it is in open circuit.
6. Resistivity of the material depends on the magnitude and direction of applied electric field.
7. In house hold electric circuits, all electric appliances drawing power are joined in parallel.
8. Electric field E and current density J having the relation $E \propto \frac{1}{J}$
9. We obtain large amounts of currents in a conductor even if the electron drift speed and electron charge is very small because of electron number density is enormous.
10. Electric bulbs in street lighting all are connected in series.
11. If external resistance R is zero in a cell then minimum current is drawn from a cell is $I = \frac{\varepsilon}{\Upsilon}$
12. In meter bridge the percentage error in unknown resistance can be minimised by adjusting the balancing point near the middle of the bridge.
13. In series a device of higher power rating consumes less power.
14. In parallel combination of resistances, the equivalent resistance is greater than larger resistance present in the combination.

MULTIPLE CHOICE QUESTIONS :

1. Which of the following characteristic of electrons determines the current in a conductor
    a. Thermal velocity alone
    b. Drift velocity alone
    c. Both thermal and drift velocities
    d. Neither thermal nor drift velocity

2. A portable compact disc player is designed to play for 2 hours on a fully charged battery pack. If the battery pack provides a total of 180 c charge, how much current does the player use in operating ?

   a. 0.025 A b. 0.25A c. 2.5 A d. 25A

3. Kirchoff's first law and second law are respectively based on

   a. Conservation of charge and conservation of momentum
   b. Conservation of energy and conservation of charge
   c. Conservation of charge and conservation of energy
   d. Conservation of momentum and conservation of charge.

4. The resistance of a wire is R. It is bent at the middle by 180^0 and both the ends are twisted together to make shorter wire. The resistance of the new wire is

   a. $\frac{R}{2}$ b. $\frac{R}{4}$ c. $\frac{R}{8}$ d.2R

5. The length of a cyclindrical wire is increased by 100%. Due to the consequent decrease in diameter, the change in the resistance of the wire will be

   a. 50 b. 100 c. 200 d. 300

6. A uniform metallic wire has a resistance of 18 and is bent into an equilateral triangle. Then the resistance between any two vertices of the triangle is

   a. 4Ω b. 2Ω c. 3Ω d. 6Ω

7. If a wire is stretched to make it 0.1% longer, then its resistance will

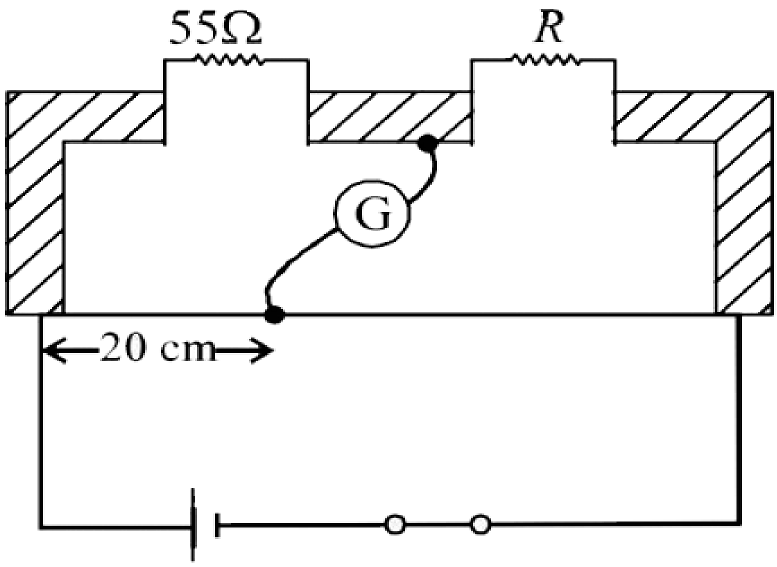
   a. Increases by 0.05%
   b. Decreases by 0.05%
   c. Increases by 0.2%
   d. Decreases by 0.2%

8. If E is the emf of a cell of internal resistance ‘r’ and external resistance R, then potential difference across R is given by

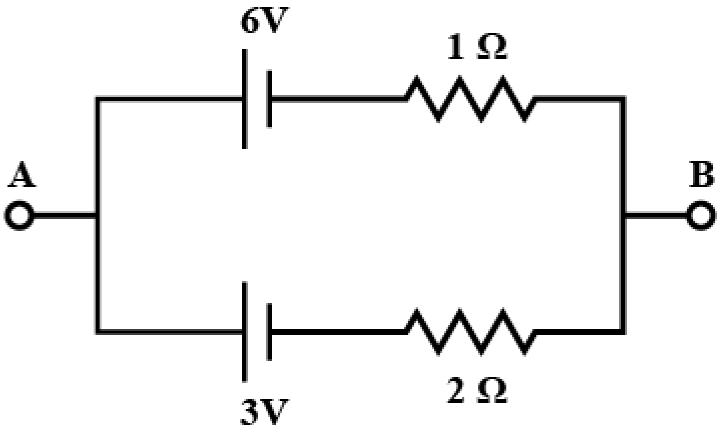
a. V = $\frac{E}{R+r}$ b. V = E c. V = $\frac{E}{(1+\frac{R}{r})}$ d. V = $\frac{E}{(1+\frac{r}{R})}$

9. Two cells of different size one big and one small are made up of same material and liquid then
    a. Big size cell has more emf and small size cell has less emf.
    b. Big size cell has less emf and small size cell has more emf.
    c. Both the cells have same emf
    d. None of the above.

10. A meter bridge setup with null deflection in the galvanometer is shown in the figure. The value of unknown resistance R is



11. Two batteries of different emfs and different internal resistances are connected as shown. The voltage across AB in volts is

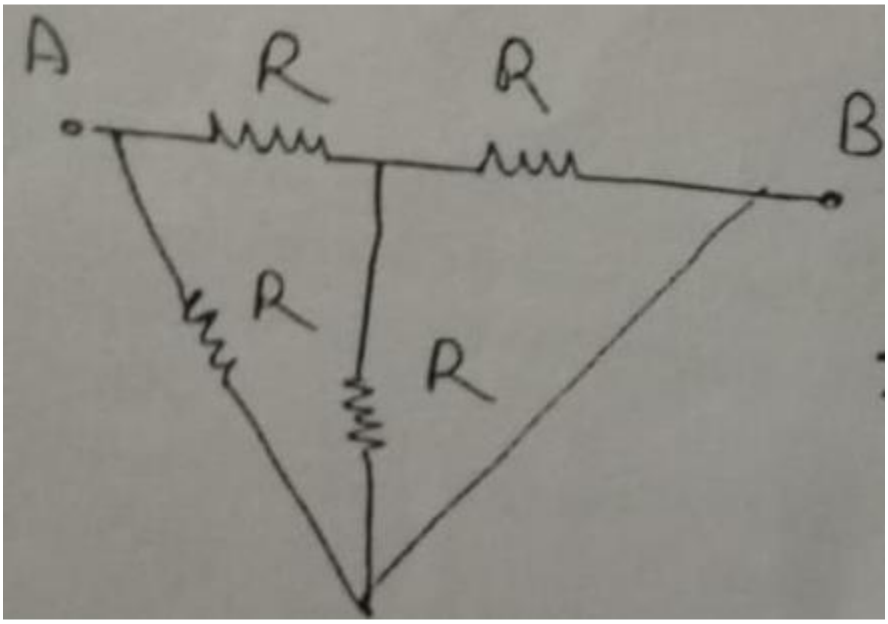


a. 5v b. 10 v c. 15v d. 2.5v

12. A long resistance wire is divided into two points then n parts are connected in series and other n parts are in parallel separately. Both combinations are connected to identical supplies. Then the ratio of heat produced in series and parallel combinations will be

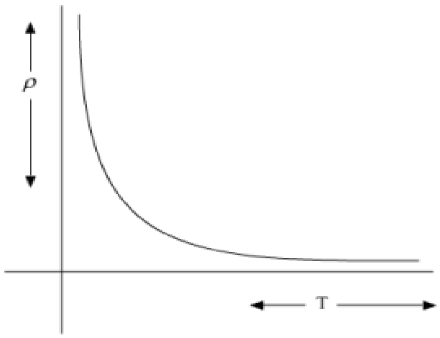
a. 1 : 1 b. 1 : n^4 c. 1 : n^2 d. n^2: 1

13. The equivalent resistance between the points A and B is



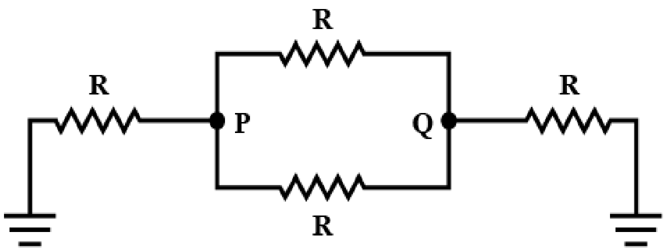
a. 2R b. $\frac{3}{4}$ R c. $\frac{4}{3}$ R d. $\frac{3}{5}$ R

14. The graph shows the variation of resistivity with temperature T. The graph can be of



a. Copper
b. Nichrome
c. Germanicum
d. Silver

15. The net resistance between points P and Q in the circuit shown in figure is



a. $\frac{R}{2}$ b. $\frac{2R}{5}$ c. $\frac{3R}{5}$ d. $\frac{R}{5}$

Assertion / Reason :

Direction : Each of the following questions contains two statements assertion and reason. These questions has four alternative choices, only one is correct answer. You have to select one of (a) (b) (c) or (d).

a) Assertion is correct, reason is correct, reason is a correct explanation of assertion.
b) Assertion is correct, reason is correct, reason is not a correct explanation of assertion.
c) Assertion is correct, reason is correct
d) Assertion is incorrect , reason is correct

1. **Assertion :** Current is a vector quantity
   Reason : Current has magnitude as well as direction.
2. **Assertion :** Current flows in a conductor only when there is an electric field with in the conductor.
   Reason : The drift velocity of electron in presence of electric field decrease.
3. **Assertion :** Bending of a wire does not effect electrical resistance.
   Reason : Resistance of the wire is proportional to resistivity of material.
4. **Assertion :** $\underset{E}{\rightarrow} = \underset{PJ}{\rightarrow}$ is the statement of Ohm's law.
   Reason : If the resistivity of conducting material is independent of the direction and magnitude of the applied field then material obeys Ohm's Law.

5. **Assertion :** The emf of the driver cell in the potentiometer experiment should be greater that the emf of the cell to be determined.

Reason : The fall of potential across the potentiometer wire should not be less than the emf of the cell to be determined.

III. Match the column I & column II

Column I	Column II
A. $\frac{e}{m}$	1. Conductivity
B. $\frac{ne^2}{m}$	2. Mobility
C. nqv_d	3. Current
D. $\frac{ne}{t}$	4. Current density

a : A → 2, B →1 , C →4 , D→ 3

b. A → 2 , B→ 4, C →1, D →3

c. A→ 3 B → 1 C→ 4 D → 2

d. A→ 3, B → 4, C→ 1, D→ 2

IV. Match the column I and column II

Column I	Column II
A. Silver	1. Wire bound resistor
B. Semi conductor	2. Resistor of higher range
C. Carbon resistor	3.Negative temperature coefficient of resistivity
D. Manganin	4. Least resistivity

a. A → 1 , B →2, C→3, D→ 4

b. A→ 1, B →3, C→ 2 ,D→ 4

c. A →4, B→ 2, C →3, D→ 1

d. A→ 4 B→, 3, C→ 2, D →1

V. Match the following

Column I	Column II
A. Ohm's law is applicable to 1.	1. Greater resistivity
B. Ohm's law is not applicable to 2.	2. Thermistor
C. Alloys have semi conductor of 3.	3. Metals
D. A heat sensitive resistor is 4.	4. Diodes, Electrolytes.

a. A→ 2, B →1, C→ 4, D→ 3

b. A→ 3, B →4, C→ 1, D→ 2

c. A→3, C→ 1, B →4, D →2

d. A→ 2, B→ 4, C→ 1 ,D →3

VI. Match the column I and column –II

Column I	Column II
A. Balanced condition of Wheatstone bridge	1. r = R ($\frac{l_1}{l_2} - 1$)
B. Determination of internal resistance of a cell	2. $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
C. Comparison of emf of two cells	3. $\frac{R}{S} = \frac{l}{100-l}$
D. Determination of unknown resistance	4. $\frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$

a. A$\rightarrow$ 3, B $\rightarrow$1, C$\rightarrow$ 4 ,D$\rightarrow$ 2

b. A $\rightarrow$3 , B $\rightarrow$4 ,C $\rightarrow$1 ,D $\rightarrow$2

c. A$\rightarrow$ 2 ,B$\rightarrow$ 1, C$\rightarrow$ 4, D $\rightarrow$3

d. A $\rightarrow$2, B$\rightarrow$ 4, C$\rightarrow$ 1, D$\rightarrow$ 3

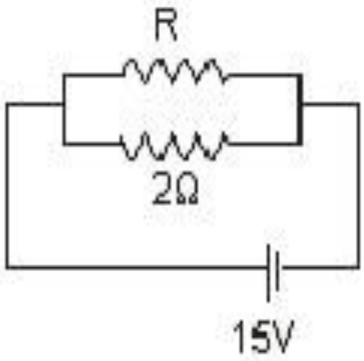
Problems :

1. An electron beam has an operature 1. 0mm^2 . A total of 6 x 10 ^{18} electrons go through any perpendicular cross section per sec then calculate current and current density in the beam ?

2. The current form 3v battery of a packet calculator is 0.17mA. In one hour of operation how much energy does the battery deliver to the calculator current 1 ?

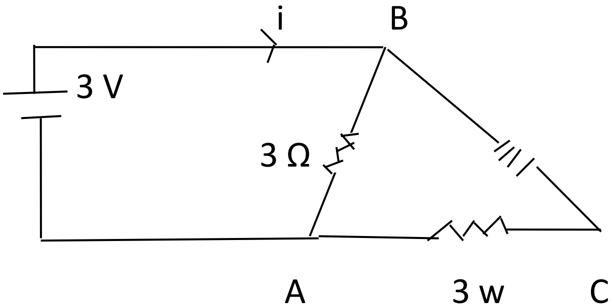
3. A wire has a resistance of 21Ω . It is melted down and from the same volume of metal a new wire is made that is 3 times longer than the original wire. What is the resistance of new wire ?

4. In the following circuit power dissipation is 150 watts then find the value of R ?

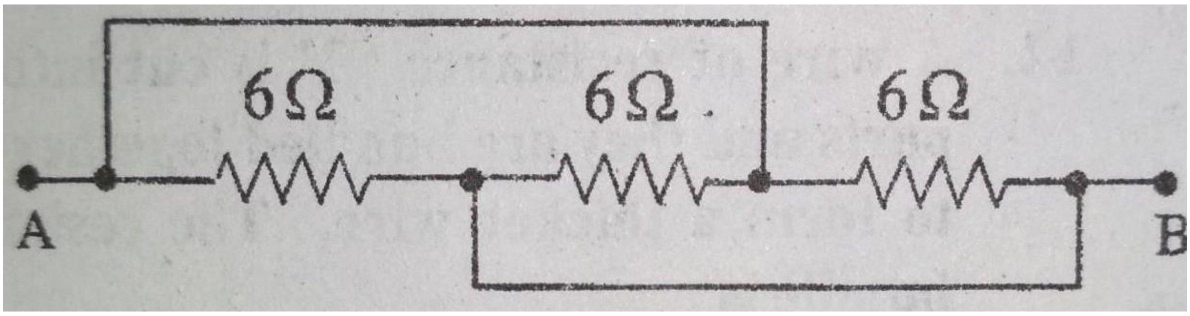


5. A wire connected to 220 v mains supply has power dissipation P_1. Now the wire is cut into two equal pieces, which one connected in parallel to the same supply, power dissipation in this case is P_2. Then find $\frac{P_2}{P_1}$.

6. Find the current i shown in the fig



7. The effective resistance between A and B in the given circuit is



8. If specific resistance of a potentiometer wire is 10^{-7} nm current flowing through it, is 0.1 amp and cross sectional area of wire is 10^{-6} m^2, then find potential gradient ?

9. If the resistance of a conductor is 5Ω at 50^0 C and 7Ω at 100^0 C, then find mean temperature coefficient of resistance of the material ?

10. In a large building there are 15 bulbs of 40 w, 5 bulbs of 100w, 5 fans of 80w and 1 heater of 1kw . The voltage of electric mains is 220v. Find the minimum capacity of the main fuse of the building ?

SOLUTIONS

FILL UP THE BLANKS

1. Voltage V
2. Constant
3. Negligible temperature coefficient of resistance
4. Resistor
5. Electrolyte
6. Remain unchanged
7. Conservative
8. 36×10^5
9. Mobility
10. 11 Ω[Hint : effective resistance : $\frac{R}{n^2}$]
11. High
12. r = R
13. Ohm
14. Current density
15. Length

True / False

01. True
02. False
03. True
04. True
05. True
06. False (It depends on nature of substance)
07. True
08. False (E α J)
09. True
10. False (These are connected in parallel)
11. False (If R = 0 , maximum current from a cell)
12. True
13. True
14. False (Equivalent resistance is smaller than smallest resistance in the combination)

Multiple Choice Questions :

1. B

   [Hint : I = ne A V_d n_1 e_1 Δ are constants then I α V_d]

2. A

   [Hint : I = $\frac{q}{t}$ $\frac{180}{2h}$ = $\frac{180}{2 \, x \, 3600}$ = 0.025 A]

3. C

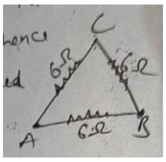
4. B

[Hint : $\frac{1}{R_e} = \frac{1}{\frac{R}{2}} + \frac{1}{\frac{R}{2}}$ R $_e$ = $\frac{R}{4}$]

5. D

[Hint : R = $\frac{\rho\, R}{A}$ = R ‘ = $\frac{\rho\,(2l)}{A\, l_2}$ = 4 R]

6. A

[Hint : 

$\frac{1}{R} = \frac{1}{12} + \frac{1}{6} = \frac{1}{4}$

7. C

[Hint : R . $\frac{S\, l^2}{A}$; $\frac{\Delta R}{R}$ = 2. $\frac{\Delta l}{l}$ = 2 x 0.1 = 0.2%

8. D

[Hint : V = I $_R$ = $\frac{E}{1+\frac{r}{R}}$]

9. C

[Hint : emf of a cell does not depend on the size of the cell]

10. B

[Hint : $\frac{55}{R} = \frac{20}{80}$ ∴ R = 220 Ω

11. A

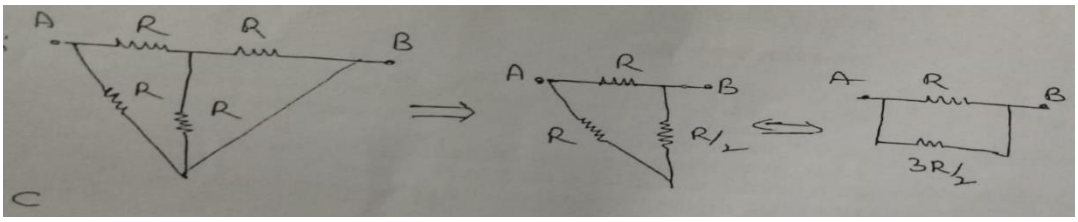
[Hint : V = $\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$ = 5 V]

12. C

[Hint : Q α $\frac{1}{R}$: $\frac{Q_s}{Q_p} = \frac{R_p}{R_s} = \frac{\frac{R}{2n^2}}{\frac{R}{2}}$ = 1 : n^2]

13. D

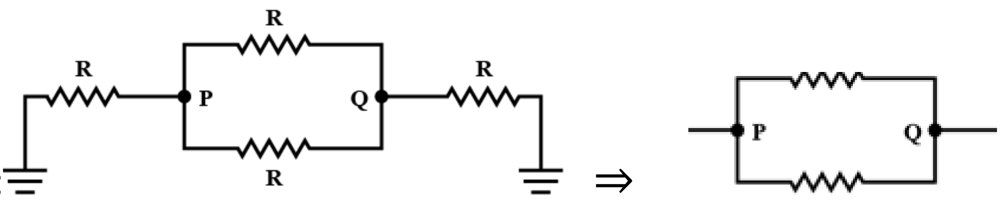
Hint :



14. C

[Hint : The resitivity of semi conductor decreases with increase in temperature]

15. B

[Hint : 

2R

Assertion / Reason

1. **D**

   Hint : Current has magnitude as well as direction but it does not obey laws of vector addition so current is a scalar quantity.

2. **C**

   Hint : When there is no electric field free electrons move randomly in the conductor. So drift velocity is zero and current is zero. In the presence of electric field free electrons accelerated from + ve end to – ve end hence current start because drift velocity increases

3. A

Hint : Resistance R = $\frac{el}{A}$ when wire is bent resistivity length and area of cross section do not change. Resistance of the wire remains same.

4. A

Hint : [V : IR ; V = $I\ \frac{\rho l}{A}$; V = j ρ l ;

$\frac{v}{l}$. J P ; E = j e

$\therefore\ \overrightarrow{E} = p\ \overrightarrow{j}$

Resitivity of the material also obey Ohm's law.

5. A

Hint : If emf of the driver cell is lesser than the emf of the experimental cell, then balance point will not obtained.

Match the following :

1. B [A→ 3, B →4, C →1, D→ 2]
2. C [A→ 2, B →1 , C→ 4, D→ 3]
3. A [A→ 2, B→ 1, C→ 4, D→ 3]
4. D [A→ 4, B→ 3, C→ 2, D→ 1]

PROBLEMS

1. 9.6×10^{-3} A and 9.6×10^{3} A/m^2

   [Hint : i. $\frac{q}{t}$ and j = $\frac{i}{A}$]

2. 1. 8 J

   [Hint : w = vq = I t x battery emf

   = 0.17mA x 1 hr x 3 = 1.8 J]

3. 189 Ω

   [Hint : $\frac{R_2}{R_1} = \frac{A_1 L_2}{L_1 A_2}$ (P is same)

   $\frac{R_2}{R_1} = \frac{3\ L_1\ X\ A_1}{L_1\ X\ A_3}$ = 9 (. $A_2 = \frac{A_1}{3}$)

   R_2 . $9R_1$ = 9 (21) = 189 Ω

4. 6

   Hint [Power P = $\frac{V^2}{R} = \frac{V^2}{\frac{2R}{2+R}}$

   $150 = \frac{15\ X\ 15}{2R}$ (2 + R)

   5R = 30 R = 6 Ω

5. 4

   Hint [$\frac{P_1}{P_2} = \frac{\frac{V^2}{R}}{\frac{V^2}{\frac{R}{4}}}$] = 4

6. 1.5A

   Hint : [BC, AC in series and this combination is parallel to AB

   $\therefore \frac{1}{R} = \frac{1}{6} + \frac{1}{3} = \frac{3}{6} \Rightarrow R = 2\ \Omega$

   I = $\frac{V}{R} = \frac{3}{2}$ = 1.5 A]

7. 2

Hint : Three 6 Ω resistances are parallel to each other

$$(\frac{1}{R} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6})$$

8. 10^{-2} v/m

Hint : [potential gradient of $\phi = \frac{P.\ d}{l} = \frac{V}{l}$

$$\phi = \frac{i\,P}{A} \quad [\ \therefore V = i\,R \text{ and } l = \frac{R\,A}{p}\ ]$$

$$\phi = \frac{0.1\,x\,10^{-7}}{10^{-6}} = 10^{-2}\ \text{V/m}$$

9. 0.001 / C

Hint [$R = R_0\,(1+ \alpha t)$

$5 = R_0\,(1+ 50\,\alpha\,)$; $7 = R_0\,(1 + 100\,\alpha\,)$

$$\frac{5}{7} = \frac{R_0\,(1+50\,\alpha)}{R_0\,(1+100\,\alpha)}$$

$5 + 500\,\alpha$; $7 + 350\,\alpha$

$\Rightarrow \alpha = 0.001$ / C]

10. Ans. 11.3 A

[Hint : Total power = (15 x 40) + (5 x 100) + (1 x 1000) = 2500w

Power P = VI $\Rightarrow$ I. $\frac{P}{V} = \frac{2500}{220}$ = 11.3A]

7. MOVING CHARGES AND MAGENITISM

Synopsis

1.A current carrying conductor produces a magnetic field in its surrounding space. This was first discovered by Oersted.

2.The direction of Magnetic Field depends on the direction ofcurrent.

3.Magnetic field can be produced by current carrying conductors or coils and by the variable electric field.

4.Stationary or static charges cannot produce magnetic field.They can produce electric field only

5.But moving electric charges can produce both electric andmagnetic fields.

6.The direction of the magnetic field can be found by

7.Ampere's swimming rule, b) Ampere's Right hand griprule and c) Maxwell's Cork Screw Rule

8.The region of space around a magnet in which it's magneticeffects are experienced can be defined as magnetic field (B)

9.The S. I Unit of "B" is Weber/meter or Tesla. It is a vectorquantity

Cyclotrons are the charged particle accelerators to highenergies

10.If there were many fields due to more charges, the resultantfield can be obtained by the principle of super position

11.The net force due to electric and magnetic fields would be aLorentz force The Lorentz Force is given by $\mathbf{F} = q\mathbf{E} + q\,(\boldsymbol{v} \times \boldsymbol{B})$

12.If a charge "q" is moving with velocity "V" in a magneticField B, then the Force acting on the charge is $\boldsymbol{F} =$

$q(\boldsymbol{V} \times \boldsymbol{B}) = qVBsin\theta$

13.If a particle can move in a circular path due to theexperience of centripetal force is mv^2/r

14.If this centripetal force is magnetic force, then $qvB = mv^2/r$and the radius of the circular path, $r= mv/Bq$

15.When E and B are crossed(perpendicular), the velocityselector V=E/B

16.Frequency of the particle in a cyclotron n = Bq/2m

17.The magnetic moment of a current carrying coil with areaA and having N turns is,

m = NIA

18.BIOT-SAVART'S LAW can be helpful to find themagnetic field due to a current carrying conductor

19.The magnetic field at a point on the axis of a circular current carrying loop having "n" turns is $B = \frac{\mu_o n I R^2}{x^2+R^2)^{3/2}}$

And at the centre of the loop (x=0), $B = \frac{\mu_o n I}{2R}$

20.Fleming's Left Hand Rule:- Fore Finger, Central Fingerand Thumb of the left hand are stretched to mutually perpendicular directions

such that, Fore finger indicates Magnetic Field, CentralFinger indicates the direction of current then thumb indicates the direction of the Force

21.Ampere's Circuit Law: The Line Integral of Magnetic Field around any closed path is equal to μ_o times the netcurrent enclosed by that path.

$\int \boldsymbol{B}.\boldsymbol{dl} = \mu_0 I$

22.A Solenoid consists of a long wire wounded on aninsulating hollow cylinder in the form of helix

23.inside the solenoid B = $\mu_0 nI$ and ii) outside thesolenoid B = 0

24.A solenoid coil joined its two ends became a toroid. Themagnetic field in a toroid is $B = \frac{\mu_0 nI}{2\pi r}$

25.The force per unit length between two straight parallel current carrying conductors separated by a distance d is,

$f = \frac{\mu_o I_1 I_2}{2\pi d}$

26.The magnetic dipole moment of a revolving electronaround the nucleus is M = evr/2

27.Torque acting on a current carrying coil placed in uniformmagnetic field T = MB sinθ.

On the other hand, if the current carrying coil is placed in non uniform magnetic field, it experiences both force andtorque.

28.Moving Coil Galvanometer principle is, when a current carrying coil is suspended in uniform radial magnetic field,it experiences a torque and hence it rotates through a deflection θ. The amount of current in the coil will be proportional to the deflection

29.A small resistance connected in parallel withGalvanometer is known as Shunt

Resistance.

30.A Galvanometer can be converted into an Ammeter byconnecting a shunt resistance parallel to it

31.A Galvanometer can be converted into Voltmeter byconnecting high resistance in series to it

32.Ideal Ammeter has zero resistance and Ideal Voltmeter hasinfinite resistance.

Short Questions

1.Who established the connection between electricity and magnetism

A.Oersted

2.Why does a compass needle get deflected when brought near a bar magnet?

A) A Magnetic Force is experienced by the bar magnet on the compass needle

3.What happens if a current carrying conductor is placed in a magnetic field?

A)It experiences a force which is given by Fleming's Left hand rule.

4.What is a solenoid?

A)Solenoid is a coil of many turns of wire wrapped in the shape of a helicalcylinder

5.What is the shape of magnetic field produced when current is passed througha straight conductor?

A)Concentric circles around the conductor

6.What kind of magnetic field is produced by a solenoid?

A)It is similar to the magnetic field produced by a bar magnet

7.What is the S.I unit of magnetic field?

A)The S.I unit of magnetic field is Tesla

8.Which human body parts produce magnetism?

A)Heart and brain due to ion currents can produce magnetism

9.A charge q is moving in a circular path of radius r in magnetic field B. Whatis the radius of the helix?

A)r=mv/Bq

10.What is the principle of cyclotron?

A)The frequency of revolution of the charged particle in the magnetic field isindependent of its energy

11.Why cyclotrons cannot be used for accelerating electrons?

A)An electron is a very lighter particle and gets very high speed which maychange their relativistic mass

12. What is the path of a particle in cyclotron?

A)Spiral trajectory

13.What is the principle in determination of specific charge of an electron?

A)Perpendicular electric and magnetic fields are applied so that net force on theelectron should be zero

14) What is the magnetic induction inside a solenoid?

A) B = $\mu_0 nI$

15)State Ampere's circuital law?

A) The line integral of magnetic field around a closed path is equal to μ_o timesthe net current enclosed by that path

16.What is the torque?

A) The physical parameter that causes turning effect

17.What is the magnetic dipole moment of an electron revolving in a circularpath?

A) M = evr/2

18.Why concave shaped poles are used in moving coil galvanometer?

A) To produce radial magnetic field so that torque acting on the coil should bemaximum

19.What is the use of shunt resistance?

A) It protects the galvanometer from large currents.

20.How do you convert a galvanometer into an ammeter?

A) By connecting a small resistance in parallel with the galvanometer.

21.How do you convert galvanometer into voltmeter?

A) By connecting high resistance in series with the galvanometer.

22.What is the resistance of an ideal ammeter and voltmeter?

A) Zero and infinity.

23.What is the relation between deflection and current in moving coilgalvanometer?

a)They are directly proportional to each other.

Fill in the blanks

1.Light waves are .. ..electromagnetic waves
2.Radio waves werediscovered by ....Hertz......
3.The cause of magnetism is................motion of electriccharges
4.The S.I units of E and B are ...N/C......and ...Tesla.....
5.Static charges can produce...electric .... Field
6.Moving charges can produce...electric ....and ...magnetic ....fields
7.Particles can be accelerated to very high energy through...cyclotron...........
8.The ratio of charge to mass of a particle is known as......specific charge.........
9.Velocity selector is given by..... v = E/B......
10.When a current carrying conductor is placed in uniform magnetic field itexperiences ...force.......
11.I gauss = ...10^{-4} ....tesla
12.A circular coil carrying current behaves like a...magnet........
13.Gauss is the unit of ...magnetic induction...........
14.The magnetic field inside a solenoid is...... $B = \mu_0 nI$ ....
15.The value of permeability of free space is $\mu_o = 4\pi \times 10^{-7} TmA^{-1}$..........
16.The dipole moment of a current loop is independent of...magnetic field .... in which it is lying.
17.The magnetic lines of force due to straight current carrying conductorare ...concentric circles around the conductor
18.A charged particle enters a magnetic field B with velocity V, the magnetic forceexperienced by it will be F = qVB sinθ...............................

Match the following

1.

Physical constants	Value
Permeabilityof free space (μ_o)	$4\pi\times10^{-7}TmA^{-1}$
Permittivity of free space (ε_0)	8.85×10^{-12} $C^2 N^{-1} m^{-2}$
Gravitationalconstant (G)	6.67×10^{-11} $N m^2 kg^{-2}$

2.

Field in tangent galvanometer	Radial magnetic field
Ammeter	low resistance
Voltmeter	high resistance
Deflection	Current is directly proportional to deflection
Field in tangent galvanometer	Radial magnetic field
Ammeter	low resistance
Voltmeter	high resistance
Deflection	Current is directly proportional to deflection

Physical quantity	Units

Cyclotron Time period	$2\pi m/qB$
Angular frequency	$qB/2\pi m$
Radius	mv/Bq
Charge Speed	qBR/m
Kinetic energy	$B^2q^2R^2/2m$

Electric field intensity (E)	Weber
Magnetic induction(B)	N/coulomb
Magnetic flux (ϕ_B)	Tesla

Electric force	qE
Magnetic force	$qvB \sin\theta$
Lorentz force	$q\mathbf{E} + q\,(\boldsymbol{v} \times \boldsymbol{B})$

True or false

1.Permittivity describes how an electric fieldeffects and is affected by the medium (…T…)

2.The S.I unit of magnetic induction is Newtonper metre square (…F..)

3.When a charge is moving in a magnetic field ifits velocity is in the same direction of B, then no force will act on the charge (…T…)

4.In a cyclotron the particle revolving frequencyand the oscillator frequency never be the same (…F..)

5.In cyclotron the un charged particles cannot beaccelerated (…T..)

6.In right hand rule, if we shown the thumb in thecurrent flowing direction then the curled fingers will indicates themagnetic field direction (…T…)

7.The magnetic induction inside a solenoid is nonuniform (…F ..)

8.Magnetic fields are generally smaller ordersthan electric fields (…T..)

9.In tangent galvanometer current is directlyproportional to the deflection (…T..)

10.The SI unit of magnetic moment is joule / tesla(…T….)

11.Ideal ammeter has infinity resistance (…F…)

12.While determining specific charge of electron, J J Thomson applied electric and magnetic fields areperpendicular to each other (…T..)

13.The magnetic dipole moment of a current carryingcircular coil is $\pi r^2 I$ (…T…)

14.When the direction of current reverses the deflection in the galvanometer will never change (…F…)

Problems

1.A circular wire having 10 turns is bound on a circular coil of radius 1 cm and acurrent of 1 ampere is passing through it . Find the magnetic induction at the centre of the coil?

2.A wire of length π mts carries a current of 1 ampere it is bent in the form of acircle find the magnetic moment of the wire?

3.A proton and helium nucleus enters into a magnetic field normal to the field withthe same velocity what is the ratio of their radii of the circular paths?

4.A wire of length one metre carries a current of 2 ampere it is placed in magneticfield 0.05T angle of 30 degrees to the field. Find the force experienced by the wire?

5.A galvanometer has a resistance of 999 ohm , shunt resistance 1 ohm , it is used to measure the current of 1 ampere, what is the current flowing through the galvanometer?

6.Two parallel conductors carrying current of 5 ampere each repel with a force of 0.25N/M . Find the distance between them?

7.If a circular coil having 100 turns and radius 10 centimetre carries a current of 1ampere find it's a magnetic dipole moment?

8.A long straight wire carries a current of 35 ampere what is the magnetic inductionfield at a distance of 20 cm from the wire?

9.A solenoid of of length 0.5 mtshas a radius of 1 centimetre and is made of 500turns it carries a current of 5 ampere what is the magnetic induction field?

10.A cyclotron oscillator frequency is 1 mega age what should be the operating magnetic field for accelerating the particle?

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WORK BOOK

CHAPTER NAME : MAGNETISM AND MATTER

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MAGNETISM AND MATTER

SYNOPSIS :

1. **Magnetism :** The property of any object by virtue of which it can attract a piece of iron (or) steel is called Magnetism.

2. **Natural Magnet :** An ore of iron (magnetite) is natural magnet. It is weak in nature doesn't have specific shape.

3. **Artificial Magnet** : A magnet which is prepared artificially is called artificial magnet. It is strong in nature and has a specific shape.

4. **Natural Magnet :** Fe_3O_4
Artificial Magnets : bar magnet, horse-shoe magnet, etc

5. **Molecular Theory :** Every molecule of magnetic substance is a complete magnet itself.

6. **Poles :** Magnet has two poles where entire magnetism assumed to be concentrated

7. **Law of Poles (Dufey's Law)** : Like poles repell each other and unlike poles attract each other.

8. **Coulomb's Inverse Square Law : F =** $\boldsymbol{\frac{\mu_0}{\pi} \quad \frac{M_1 M_2}{d^2}}$

9. Relative permeability $\boldsymbol{\mu_r} = \frac{\mu}{\mu_0}$
$\boldsymbol{\mu}$ = absolute permeability
$\boldsymbol{\mu_0} =$ Permeability of air (or) vaccum.

10. Magnetic Length $= \frac{5}{6}$ x geometric length

11. Magnetic moment M = where m =2l x m amp. m^2 pole strength in amp. Metre
12. If two magnets of magnetic moments M_1, M_2 kept at an angle with the poles touching M' = $\sqrt{M_1^2 + M_2^2 + 2 M_1 M_2 \cos\theta}$
[M' = $\sqrt{M_1^2 + M_2^2 - 2 M_1 M_2 \cos\theta}$ unlike poles touch each other]
13. Magnetic field strength B = F / M tesla (or) w / m^2
14. Magnetic field lines forms closed loops i. e. monopoles do not exist.

15. Flux density $B = \frac{\emptyset}{A}$
16. Magnetic induction on axial line due to a short bar magnet $B_a = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$
17. Magnetic Induction on equatorial line $B_e = \frac{\mu_0}{4\pi} \frac{M}{d^3}$
18. Couple acting on a bar magnet in uniform magnetic field C = MB sin θ
19. Potential energy of a bar magnet U = - MB cos θ
20. Three parameters specifies earth's magnetism are magnetic declination (θ), magnetic dip (δ) ,horizontal component of earth's magnetic field (B_M)

    $B_H = B \cos \delta$

    $B_V = B \sin \delta$

    $B = \sqrt{B_H^2 + B_V^2}$

    $\text{Tan } \delta = \frac{B_V}{B_H}$
21. Relation between angle of dip and magnetic latitude tan δ = 2 tan λ
22. If δ is the true dip and δ_1 and δ_2 are two apparent dips in perpendicular plane then

    $\cot^2 \delta_1 + \cot^2 \delta_2 = \cot^2 \delta$
23. **Isogonic lines** : Lines connecting places have same declination, zero declination lines (agonic)
24. **Isoclinic lines** : Lines connecting the places of equal dip , zero dip lines (alinic lines)
25. **Isodynamic lines** : Lines connecting equal PH value.
26. **Hysteresis** : The lagging of intensity of magnetisation behind the magnetising field intensity is called hysteresis.

    Area of hysteresis curve gives the loss of energy per unit volume of specimen per one cycle of magnetisation.
27. Magnetic materials are three types , they are dia , para, fierro,

    Dia Materials : Cu, Ag, H_2O

    Para Materials : Al, Mn, Pt etc

    Ferro Materials : Fe, CO, Ni etc

FILL IN THE BLANKS

1. The geometric length of the bar magnet (Gl) is 30 cm then the magnetic length (ml) is ___________
2. A bar magnet of magnetic moment (M) is bent into 'U' shape such that all parts are in equal lengths then its new magnetic moment is ____________
3. The temperature at which ferro magnetic material becomes paramagnetic material

    ____
4. When a bar magnet of magnetic moment cut into 'n'pieces transversely then new magnetic moment of each piece is _________

5. Name the property due to which an iron bar behaves as magnet when iron bar brought near to the magnet _____________.
6. The path of the unit north pole in the magnetic field is known as __________
7. The C. G. S. unit of magnetic flux is _________
8. The phenomena of diamagnetism in super conductor is known as ____________
9. The dipole moment of a coil of area ‘A’ no. of terms ‘n’ and carrying current ‘C’ will be ___________
10. The process in which the length of a ferromagnetic material increases when magnetised ____________
11. If force between two magnetic poles is F, then the force between the same poles when distance is halved is _______________
12. A magnet of magnetic moment 50 i amp. m^2 is placed along the x-axis in magnetic field B = 0.5 i + 3.0j then torque acting on a magnet is _____________
13. If the relative permeability of iron is 2000. Its absolute permeability in S. I. units is _____________
14. A bar magnet of moment M is bent into ‘ S’ shape . If the length of each part is same its new magnetic moment will be __________
15. At 45^0 to the magnetic meridian the apparent dip is 30^0 then the true dip is _______

Answers :

1. 20 cm	8. Meissner effect
2. 2. M/3	9. iAN
3. 3. Curie temperature	10. Magnatostriction
4. M/n	11. 4 F
5. Induction property	12. 150 K. nm
6. Magnetic lines of force	13. $8\pi \times 10^{-4}$ H /M
7. Maxwell	14. M $/\sqrt{5}$

15. $\delta = \tan^{-1}\sqrt{\frac{1}{6}}$

OBJECTIVE QUESTIONS :

1. A freely suspended iron bar always shows north-south direction due to the property
a) Attractive property
b) Directive property
c) Inductive property
d) All of the above [ ]
2. The line joining the poles of the bar magnet is called [ ]
a) Axial line b) magnetic meridian c) geographical meridian d) equatorial line
3. Units of permeability [ ]

a) N/ amp^2 b) henry / metre c) 1kg $metre/sec^2/amp^2$ d) all the above

4. The ratio of magnetic length of the bar magnet to geometric length is [ ]
   a) 5 : 6 b) 6 : 5 c) 3 : 5 d) 5 : 3

b) The force of repulsion on a unit pole by a similar pole placed at a distance of 1m in free space is [ ]
   a) 10^{7} N b) 10^{-7} n c) 4π x 10^{-7} N d) 4π x 10^{7} N

6 . The declination (D) is [ ]

a) Greater at higher altitudes
b) Greater at equator
c) Smaller at equator
d) Both a and c

7.The elements of earth magnetic field are [ ]

a) Declination b) Inclination c) B_H d) all the above

8. The horizontal and vertical component of earth's magnetic field are H_e, V_e and ' I' is dip at a point then tan I = [ ]

   $a)\frac{v_e}{H_e}$ b) $\frac{H_e}{v_e}$ c) $H_e Z_e$ D) $\frac{H_E^2}{Z_E^2}$

9. What happens to the compass needle capable of moving in horizontal plane at the poles of earth pointing [ ]
   a)N – S direction b) E – W direction c) N – E direction d) in any direction

10. Name the instrument which is used at poles [ ]
    a)Dip needle b) compass needle c) both a and b d) none of the above

11. Name the quantity which is a measure of how magnetic material responds to an external field [ ]
    a)Permeability b) relative permeability c) susceptibility d)curie temperature

12. Suitable material for permanent magnet is [ ]
    a) Steel b) Alnico c) cobalt d) all the above

13. Universal magnetic property is [ ]
    a) Ferro - b. para c. dia d. electro-magnetic property

14. The use of hysteresis curve is to select suitable material for [ ]
    a) Permanent magnet b) electro magnet c) both a and b d) none of the above.

15. The primary origin of magnetism lies in [ ]
    i. Spinning of electron
    ii. Revolution of electron
    iii. Both a and b
    iv. None of the above

16. The magnetic moment of semi-circular magnet of the radius (r) and poles – strength (m) is [ ]

a) $2r^2$ m b. r^2m c. 2rm d. rm

17. A magnetic needle is kept in a non-uniform magnetic field experiences [ ]

a. A torque but not a force
b. Neither a force nor a torque
c. A force and a torque
d. A force but not torque

18. In a hydrogen atom the electron revolves round the nucleus 6.8×10^{15} times/sec in an orbitrary ratius 0.53 A^0. What is the equivalent magnetic moment [ ]
($e = 1.6 \times 10^{-19}$ e)

a) 9.7×10^{-24} amp x m^2 b) 7.9×10^{-24} amp x m^2
c) $9.7 \times 10^{+24}$ amp x m^2 d) $7.9 \times 10^{+24}$ amp x m^2

19. Two like poles of strength 49×10^{-3} amp. Metre and 9×10^{-3} amp. Metre are separated by a distance of 10 cm. Find the distance of the neutral point from the weaker pole. [ ]

a. 7 cm b. 5 cm c. cm d 0.3 cm

20. The horizontal component of earth's magnetic induction at a place is 0.32×10^{-4} tesla. The angle of dip at the point is 600 then find the value of vertical component of earth's magnetic field [ ]

a. 0.55×10^{-4} tesla b. 5.5×10^{-4} tesla
c. 550×10^{-4} tesla d. 0.055×10^{-4} tesla

Answers :

1. b	2. a	3. a	4.a	5.b	6. D	7. D
8. a	9. d	10. a	11.c	12.d	13.c	14.c
15. c	16. c	17. c	18. C	19. C		20. a

TRUE OF FALSE :

1. Magnetic phenomena is universal in nature.
2. Naturally occurring ore of iron (magnetite called as load stem)
3. Isolated magnetic poles do not exist
4. The magnetic field lines of bar-magnet form continuous closed loops
5. The tangent drawn to the field line at a given point represents the direction of net magnetic field at that point
6. The net magnetic flux through any closed surface ( ) is Gauss Law in Magnetism
7. Natural magnets are stronger than artificial magnets
8. Imaginary vertical plane passing through the axis of freely suspended magnet is called magnetic meridian

9. Repulsion is sure- list for magnetism .
10. The lines of force (magnetic field lines intersect with each other)
11. Magnetic moment is a vector quantity and is directed from south pole to north pole along the axis of bar magnet
12. The vertical plane at a given place containing longitude circle and geographic axis of earth is called geographic meridian
13. The axis of earths magnet makes an angle about 11.3 ^{0} with earths axis of rotation
14. Earth's magnetic field at a given place is found to be change with time.
15. The intensity of magnetising field (h) is independent of medium .
16. Magnetic susceptiability is a vector quantity.
17. Soft iron is used to made transformer core.
18. The amount of magnetic field retained in the sample when magnetising force (H) = 0 is called retentivity.
19. Coercivity is that value of H in opposite direction which makes retained magnetic field is zero.
20. The area under BH curve is very small for soft iron on comparing with steel.

1. T	2. T	3.T	4.T	5.T
6.T	7.F	8.T	9.T	10.F
11. T	12.T	13.T	14.T	15.T
16.F	17.T	18.T	19.T	20.T

Matching : Match the material with relative permitivity

	A		B
1.	Air or free space	[ ]	a) $\mu_r >> 1$
2.	Dia- magnetism	[ ]	b) $\mu_r > 1$
3.	Para Magnetism	[ ]	c) $\mu_r = 1$
4.	Ferro Magnetism	[ ]	d) $\mu_r < 1$

Match the units with their physical quantities :

A		**B**
1. Magnetisation	( )	a) weber
2. Magnetic Moment	( )	b) weber/metre ^{2} (or)
3. Magnetic flux	( )	c) Ampere/ metre
4. Magnetic flux density	( )	D) Ampere . metre ^{2}

3**. Compare the quantities with their formulae**

1. Intensity of magnetizing field (M)	[ ]	a) M/V
2. Intensity of Magnetisation (I)	[ ]	b) I/H
3. Magnetic Susceptability	[ ]	c) B / u_0
4. Permeability (- μ)	[ ]	d) u_0 [1 + x]

4. **If magnetic dip is Ø then Match the following**

A	B
1. Horizontal component of earth's magnetic field (BH)	a) $\frac{B_V}{B_H}$
2. Vertical component of earth's magnetic field (BV)	b) B sin Ø
3. Resultant Magnetic field of earth (B)	c) B cos Ø
4 Tan Ø	d)B = $\sqrt{B_H^2 + B_V^2}$

5. Match the lines connecting corresponding values.

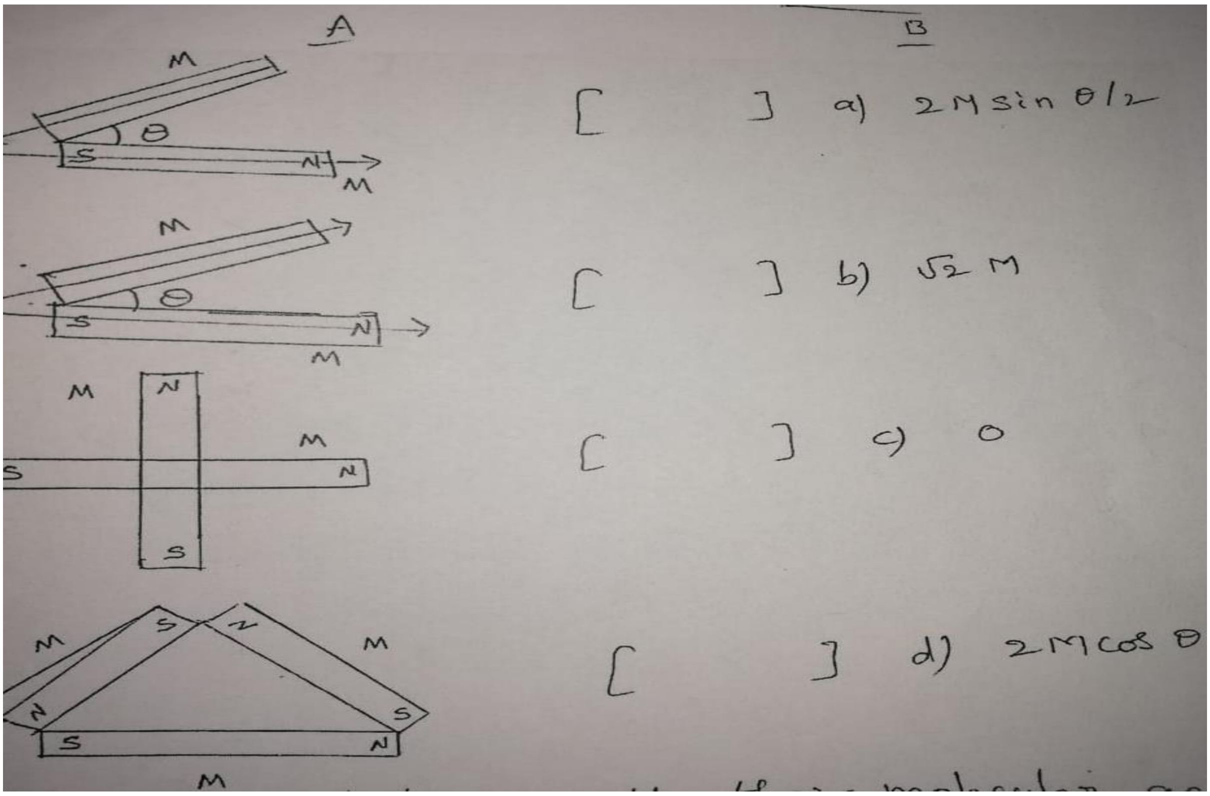
A		B
1. Isodynnamic lines	[ ]	a) zero declination
2. Aclinic lines	[ ]	b) zero dip
3. Isogonic lines	[ ]	same B_H
4. Agonic lines	[ ]	same declination

6**. Match the values of couple with their angles.**

A		B
1. $\theta = 0^0$	[ ]	a) C = MB
2. $\theta = 30^0$	[ ]	b) C = $\frac{\sqrt{3}}{2}$ MB
3. $\theta = 60^0$	[ ]	c) C = 0
4. $\theta = 90^0$	[ ]	a) C = $\frac{MB}{2}$

7. Match the resultant magnetic moments of below arrangement of magnets.

A **B**



8. Match the substances with their molecular actions : -

A		B
1.Dia magnetic substances	[ ]	(a) domains are formed
2.Para magnetic substances	[ ]	(b) orbital motion of electrons effected
3.Ferro magnetic substances	[ ]	c) Tiny atomic magnets are formed.

Answers :

1. 1 – c, 2- d 3 – b 4 – a
2. 1 – c, 2- d 3 – a 4 – b
3. 1 – c, 2- a 3 – b 4 – d
4. 1 – c, 2- b 3 – d 4 – a
5. 1 – c, 2- d 3 – d 4 – a
6. 1 – c, 2- d 3 – b 4 – a
7. 1 – d, 2- a 3 – b 4 – c

8. 1 – b, 2- c 3 – a

LEVEL – 1

1.What is the magnetic moment of semi-circular magnet of radius(r)and pole strength (m).

2.If the maximum couple acting on a magnet in a field of induction 0.2 tesla is 10 m. m. what is its magnetic moment.

3.What is the magnetic induction due to a magnet of magnetic moment 1. 25 am^2 at a distance of 0.5 m from its centre on the axial line.

4.In certain place the horizontal component of magnetic field is $\frac{1}{\sqrt{3}}$ times vertical component. What is the angle of dip at that place .

5.Two magnets have moments are in the ratio x : y and their lengths in the ratio x : z . Find the ratio of their pole strength.

LEVEL – 2

1. A short bar magnet produces magnetic fields of equal induction at two points one on the axial line and the other on the equatorial line. What is the ratio of their distances
2. A very long magnet of pole strength 4 amp.metre is placed vertically with its one pole on the table. At what distance from the pole will there be a neutral point on the table. (B_H = 4 x 10 $^{-5}$ w /m^2)
3. A bar magnet of magnetic moment 100 Amp. m^2 is bent at its mid point such that two parts make an angle 60^0 then what is the new magnetic moment.
4. Two points A and B are located at distances 20 cm and 30 cm from the centre of a bar magnet on its axial line. Find the ratio of magnetic induction at A and B.
5. Two south poles of pole strength 0.4 amp. M and 6.4 amp. M are separated by a distance of 20 cm. Find the distance of neutral point between them from pole of greater pole strength.

LEVEL – 1 KEY :

1. M = 2l x m = 2rm

2. C_{max} = MB ⇒ M = $\frac{C}{B}$

   M = $\frac{10}{0.2}$

   M = 50 amp m^2

3. B = $\frac{\mu_0}{4\pi}\ \frac{2M}{d^3}$

   B = $\frac{4\pi\ x\ 10^{-7}}{4\pi}$ x $\frac{2\ x\ (\ 1.25)}{0.5\ x\ 0.5\ x\ 0.5}$ = 20 x 10 -7 tesla

4. $\tan\delta = \frac{B_V}{B_{\ H}}$

$\tan\delta = \frac{V_3 B_H}{B_H}$ $(\therefore \frac{1}{\sqrt{3}}\ B_v = B_H)$

$\delta = 60^0$

5. $\frac{M_1}{M_2} = \frac{2\ l_1 m_1}{2 l_2 m_2}$

$\Rightarrow \frac{x}{y} = (\frac{x}{Z})\ (\frac{M_1}{M_2})$

$\Rightarrow \frac{M_1}{M_2} = \frac{Z}{y}$

$\Rightarrow$ $m_1 : m_2 = z : y$

Level – II KEY :

1. $\frac{\mu_0}{4\pi}\ \frac{2M}{d_1^3} = \frac{\mu_0}{4\pi}\ \frac{M}{d_2^3}$ (B axial = B equatorial)

$\frac{d_1^3}{d_2^3} = \frac{\mathbf{2}}{\mathbf{1}}$

$\frac{d_1}{d_2} = \frac{2^{\frac{1}{3}}}{1}$ **(or)** $2^{\frac{1}{3}} : 1$

$\therefore$ $\mathbf{d_1 : d_2 =}\ 2^{\frac{1}{3}} : 1$

2. $B_M = \frac{\mu_0}{4\pi}\ \frac{M}{d^2}$ $\Rightarrow 4 \times 10^{-5}$

$= \frac{10^{-7}(u)}{d^2}$

= d = 0.1m

3. M ‘ = M sin

M ‘ = 100 x sin $\frac{60}{2}$

M ‘ = 100 x sin 30^0

M’ = 50 amp. m^2

4. B $\propto \frac{1}{d^3}$

$\frac{B_1}{B_2} = \frac{d_2^3}{d_1^3} = \frac{30^3}{20^3} = \frac{27}{8}$

$\Rightarrow B_1 : B_2 = 27 : 8$

5. x = $\frac{d}{\sqrt{\frac{m_2}{m_1}}} + 1$

6. = $\frac{10}{\sqrt{\frac{6.4}{0.4}}} + 1 = 2$ cm

∴ Neutral point from strong pole = d – x = 10 – 2 = 8 CMS

[redacted]

Synopsis:

Electromagnetic induction:

Electromagnetic Induction is a phenomenon due to which an induced emf is set-up in a conductor or in an electric circuit on changing the magnetic flux linked with it.

Magnetic flux (ϕ_B):

1. The magnetic flux linked with a given surface area is defined as the total number of magnetic field lines passing normally through the given area.
2. Mathematically $\phi_B = \oint \vec{B}.\vec{ds} = \oint B \cdot ds \cdot \cos\theta$.
3. Magnetic flux is a scalar quantity.
4. Outward magnetic flux is taken as positive (i.e. $\theta < 90^\circ$) and inward flux is taken as negative (i.e. $\theta > 90^\circ$).
5. SI unit of magnetic flux is $Weber\ or\ Tm^2$.
6. Dimensional formula of magnetic flux is $ML^2T^{-2}A^{-1}$.

Faraday's law:

The magnitude of induced emf in a circuit is equal to the rate of change of magnetic flux through the circuit $E = -\frac{d\phi_B}{dt}$.

For N turns $E = -N\frac{d\phi_B}{dt}$.

Induced charge $dq = idt = \frac{E}{R}dt = \frac{-N\frac{d\phi_B}{dt}}{R}dt = -\frac{N}{R}d\phi_B$.

Lenz's law:

- This law states that the direction of induced current in a circuit is so as to oppose the cause of change in the magnetic flux.
- Lenz's law is strictly in accordance with the law of conservation of energy.

Motional emf:

1. Let a conducting rod of length l be moving with uniform velocity v perpendicular to a uniform magnetic field B, an induced emf will be set-up and the magnitude of the induced emf will be $E = Blv$.
2. If rod is moving such that it makes an angle θ with the direction of magnetic field, then $E = Blv\sin\theta = l\,(\vec{B} \times \vec{v})$.
3. Hence for the motion parallel to the direction of B, the induced emf is 0.

Motional emf in a loop:

If a conducting rod moves on two parallel conducting rails then an emf is induced $E = Blv$, induced current $i = \frac{E}{R} = \frac{Blv}{R}$.

Rotational emf:

Let a conducting rod of length l rotate about an axis passing through one of its ends with an angular velocity ω in a plane perpendicular to magnetic field B, then an induced emf is set-up between the ends of the rod whose magnitude is given by $E = \frac{1}{2}Bl^2\omega$.

Self-induction:

It is phenomenon due to which an induced emf is set-up in a coil or a circuit, whenever current passing through it changes, an induced emf opposes the change that caused it and is thus know as back emf.

Self-inductance:

1. Flux linked with coil is $N\phi_B \propto i$ or $N\phi_B = Li$, Where L is a constant known as the coefficient of self-induction or self-inductance of given coil.
2. It may be defined as the magnetic flux linked with the coil when a constant current of 1A is passed through it.
3. Induced emf due to self-induction $E = -N\frac{d\phi_B}{dt} = -L\frac{di}{dt}$
4. SI unit is Henry(H).

Magnetic potential energy of an inductor:

The work done is stored as magnetic potential energy of that inductor $U = \frac{1}{2}Li^2$.

Formulae for self-inductance:

1. For a circular coil of radius R and N turns, the self-inductance $L = \frac{1}{2}\mu_0 \pi N^2 R$.
2. For solenoid of coil having length l, total number of turns N and cross-sectional area A $L = \frac{\mu_0 N^2 A}{l} = \mu_0 n^2 A l$ where $n = \frac{N}{l}$.
3. For a toroid of radius R and number of turns N, $L = \frac{1}{2}\mu_0 N^2 R$.
4. For a square coil of side, a and number of turns N, $L = \frac{2\sqrt{2}}{\pi}\mu_0 N^2 a$.

Mutual induction:

Mutual induction is the phenomenon due to which an emf is induced in a coil when the current flowing through a neighbouring coil changes.

Mutual inductance:

1. Mutual inductance of a pair of coils is defined as magnetic flux linked with one coil when a constant current of unit magnitude flows through the other coil $N\,\phi_{B_2} = Mi_1$.
2. Induced emf due to mutual inductance $E = -N\frac{d\phi_{B_2}}{dt} = -M\frac{di_1}{dt}$
3. SI unit is Henry.
4. Coupling coefficient $k = \frac{\text{magnetic flux linked with secondary coil}}{\text{magnetic flux developed in the primary coil}}$
5. It is observed that $0 \le k \le 1$.
6. For a pair of two magnetically coupled coils of self-inductance L_1 and L_2respectively, the mutual inductance $M_{12} = M_{21} = M = k\sqrt{L_1 L_2}$.

Formulae for Mutual Inductance:

1. For pair of two solenoid coils wound one over the other

$$M = \frac{\mu_0 N_1 N_2 A}{l}$$

2. For a pair of concentric coplanar square coils

$$M = \frac{2\sqrt{2}\,\mu_0\, N_1\, N_2\, a^2}{\pi\, b}$$

$$a = side\ of\ smaller\ coil$$
$$b = side\ of\ larger\ coil$$

3. Mutual inductance of a pair of concentric circular coils is

$$M = \frac{\mu_0\, N_1\, N_2 \pi\, r^2}{2R}$$

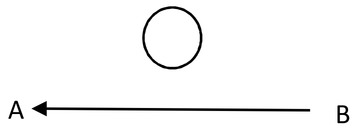
$$r = radius\ of\ smaller\ coil$$
$$R = radius\ of\ larger\ coil$$

Eddy Currents (or) Foucault Currents:

1. The induced circulating currents produced in a conductor itself due to change in magnetic flux linked with the conductor are called eddy currents.
2. The production of eddy currents in a metallic conductor leads to loss of electric energy in the form of heat energy.
3. Eddy currents can be minimized by taking the metal core in the form of a combination of thin laminated sheets or by slotting process
4. Electric brake, speedometer, electric induction furnace, AC induction motor and electrical energy meter make use of the concept of eddy currents.

I. Very short question and answers:

1) Define self-inductance of a coil.
2) The electric current is flowing in a wire in the direction from B to A. Find out the direction of the induced current in the metallic loop kept near the wire as shown in the figure



3) State Lenz's law
4) Define magnetic flux
5) State Faraday's Law of Electromagnetic Induction
6) Define Electromagnetic induction
7) What are eddy currents
8) Define mutual induction
9) What is motional emf
10) Name the phenomena in which a current is induced in a coil due to change in magnetic flux linked with it
11) What does magnetic flux measure?
12) What is the SI unit of magnetic flux?
13) When is the flux through a surface a) maximum b) zero?
14) What does negative sign in the expression, $E = -\frac{d\phi_B}{dt}$, imply?
15) Why are eddy currents undesirable?

II. Answer True or False:

1) An electric motor converts mechanical energy into electrical energy.
2) An electric generator works on the principle of electromagnetic induction.
3) The field at the centre of a long circular coil carrying current will be a parallel straight line.
4) A wire with a green insulation is usually the live wire of an electric supply.
5) AC generator has sliprings while DC generator has a commutator.
6) The magnitude of induced current can be increased by increasing the number of turns in the coil.
7) Joseph Henry invented the electromagnetic motor.
8) Magnetic flux is a vector quantity.
9) SI unit of magnetic flux is Tesla.
10) Faraday discovered Electromagnetic Induction.
11) The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.
12) The induced emf $'Blv'$ is called motional emf.
13) Eddy currents are generated in PVC pipe
14) Inductance is a scalar quantity.
15) Inductance is the ratio of the flux linkage to current.

III. Fill up the blanks:

1) The total magnetic flux through a closed surface is______________.
2) The induced emf in a closed loop equals the negative of the time rate change of ______________ through the loop.
3) The induced emf Blv is called ______________.

4) CGS unit of magnetic flux is______________.
5) The direction of any______________is such as to oppose the cause of the effect.
6) A potential difference is maintained between the ends of a conductor as long as the conductor continues to move through the______________.
7) Eddy currents have both practical useful applications as well as______________effects.
8) A wire in the form of a coil can server as an______________.
9) When current in coil changes, magnetic flux changes and an induced emf is setup, this is called ______________.
10) When current in coil changes, magnetic flux changes and an emf is induced in neighbouring coil, this is called______________.
11) An electrical machine used to convert mechanical energy into electrical energy is______________.
12) Relative motion between______________and the coil results in generation of electric current in the coil.
13) Two coils are placed close to each other. The mutual inductance of pair of coils depends on ______________.
14) Lenz's law of electromagnetic induction is as per______________.
15) Relation between SI and CGS unit of magnetic flux is______________.
16) Direction of induced current is such that it______________the cause which produced it.

IV. Multiple Choice Questions:

1) The north pole of a long bar magnet was pushed slowly into a short solenoid connected to a galvanometer. The maximum deflection of galvanometer was observed when the magnet was
   a) moving towards the solenoid
   b) moving into the solenoid
   c) at rest inside the solenoid
   d) moving out of the solenoid
2) Faraday's laws are consequence of the law of conservation of
   a) Energy b) charge c) magnetic field d) both a and c
3) Two identical co-axial coils P and Q carrying equal amount of current in the same direction are brought closer, the current in
   a) P increases while in Q decreases
   b) Q increases while in P decreases
   c) Both P an Q increases
   d) Both P an Q decreases
4) Direction of current induced in a wire moving in a magnetic field is found using
   a) Fleming's left-hand rule
   b) Fleming's right-hand rule
   c) Ampere's rule
   d) right hand clasp rule
5) A solenoid is connected to a battery so that a steady current flows through it, if an iron core is inserted into the solenoid the current in it will
   a) Increase b) decrease c) remain same d) first increase then decrease

6) If a coil carrying an electric current is placed in a uniform magnetic field, then
   a) emf is produced
   b) torque is produced
   c) both a and b
   d) torque is not produced
7) If the magnetic field is parallel to a surface, then magnetic flux through the surface is
   a) Zero b) small but not zero c) infinite d) large but not infinite
8) In electromagnetic induction, the induced charge in a coil is independent of
   a) Change in flux b) time c) resistance d) frequency
9) The total charge induced in a conducting loop when it is moved in a magnetic field depends on
   a) The rate of change of flux
   b) Initial magnetic flux only
   c) The total change of flux
   d) Final magnetic flux only
10) Eddy currents do not cause
   a) Damping b) heating c) sparking d) loss of energy
11) Which of the following is not an application of eddy currents?
   a) Induction furnace
   b) crystallography
   c) galvanometer damping
   d) speedometer in automobile
12) Induction furnaces are based on
   a) Self-induction b) mutual induction c) eddy currents d) None of these
13) The role of self-inductance in a circuit is equivalent to
   a) Momentum b) force c) energy d) inertia
14) If N is the number of turns in a coil, the value of self-inductance varies as
   a) N^0 b) N c) N^2 d) N^{-2}
15) Energy needed to establish a direct current i in a coil of self-inductance L is
   a) $L\frac{di}{dt}$ b) $\frac{1}{2}Li^2$ c) $\frac{1}{2}iL^2$ d) zero
15) The mutual inductance between two coils depends on
   a) medium between the coils
   b) separation between the coils
   c) orientation of coils
   d) all of the above factors
16) Which of the following is not a factor to determine the mutual inductance of two coils?
   a) number of turns of each coil
   b) the shape of each coil
   c) current through each coil
   d) separation between the coils
17) Two coils of self-inductance L_1 and L_2 are placed so close together that the effective flux in one coil is completely linked with the other. If M is the mutual inductance between them, then
   a) $M = L_1L_2$ b) $M = \frac{L_1}{L_2}$ c) $L_1^2L_2^2 = M$ d) $M = \sqrt{L_1L_2}$

18) Energy in a current carrying coil is stored in the form of

a) electric field b) magnetic field c) heat d) dielectric strength

19) When two mutually perpendicular alternating magnetic fields superimpose on each other, the resulting field is

a) linear b) stationary c) rotating d) alternating

V. Match the following

1)

i.	Magnetic flux	a. M
ii.	Emf	b. L
iii.	Mutual inductance	c. $\emptyset_B$
iv.	Self-inductance	d. E

2)

i.	$ML^2T^{-2}A^{-1}$	a. Self-inductance
ii.	$ML^2T^{-3}A^{-1}$	b. Magnetic flux
iii.	$ML^2T^{-2}A^{-2}$	c. Mutual inductance
iv.	$ML^2T^{-2}A^{-2}$	d. EMF

3)

i.	Magnetic flux	a. $E = -N\frac{d\emptyset_B}{dt}$
ii.	Mutual inductance	b. $\emptyset = \vec{B}\cdot\vec{A}$
iii.	EMF	c. $E_1 = -M_{12}\frac{di_2}{dt}$
iv.	Self-inductance	d. $E = -L\frac{di}{dt}$

4)

i.	Faraday's law	a. $\mu_0 n^2 Al$
ii.	Motional emf	b. $\mu_0 n_1 n_2 (\pi r_1{}^2) l$
iii.	Mutual inductance	c. Blv
iv.	Self-inductance	d. $E = -N\frac{d\emptyset_B}{dt}$

5)

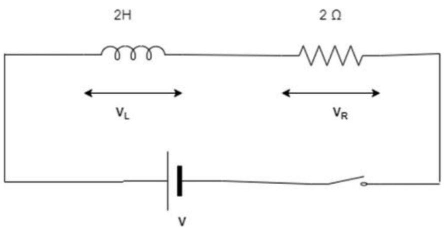
i.	Lenz's law	a. Blv
ii.	Energy stored in an inductor	b. $-\frac{d\emptyset}{dt}$
iii.	Motional emf	c. Electrical inertia
iv.	Inductance	d. $\frac{1}{2}Li^2$
		e. $\frac{1}{2}CV^2$

6)

i.	Magnetic induction	a. MT^2A^{-1}
ii.	Coefficient of self-induction	b. L^2T^{-2}
iii.	LC	c. $ML^2T^{-2}A^{-2}$
iv.	Magnetic flux	d. None of the above

7)

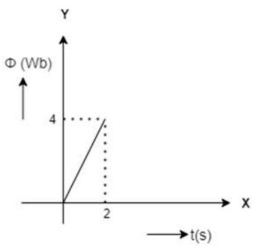
In the circuit shown in fig., switch is closed at t=0, Then



i.	$V_L\ at\ t = 0$	a.	Zero
ii.	$V_R\ at\ t = 0$	b.	10V
iii.	$V_L\ at\ t = 1s$	c.	$\frac{10}{e}V$
iv.	$V_R\ at\ t = 1s$	d.	$(1 - \frac{1}{e})10V$

8)

Magnetic flux passing through a coil of resistance 2Ω is as shown in fig., In second column, all values are in SI units.



i.	Induced emf	a.	4
ii.	Induced current	b.	1
iii.	Charge flow in 2s	c.	8
iv.	Heat generated in 2s	d.	2

9)

i.	Lenz's law	a.	Coefficient of self-induction
ii.	Rate of change of magnetic flux	b.	Electrical inertia
iii.	Total magnetic flux linked with coil	c.	Induced emf
iv.	Inductance	d.	Law of conservation of energy

VI. Problems (Level – I)

1) Current in a circuit falls from 5.0 A to 0 A in 0.1s. If an average emf of 200V is induced. Give an estimate of self-inductance of the circuit.
2) A pair of adjacent coils has a mutual inductance of 1.5 H. If current in one coil changes from 0 to 20A in 0.5s, what is the change of flux linkage with the other coil?

3) What inductance would be needed to store 1.0 kWh of energy in a coil carrying 200 A current?
4) A straight solenoid has 50 turns per cm in primary and 200 turns in the secondary, the area of cross section of solenoid is $4cm^2$. Calculate the mutual inductance.
5) A circular coil of diameter 21cm is placed in a magnetic field of induction $10^{-4}\ T$.The magnitude of flux linked with the coil when plane of coil makes 30° angle with the field is
6) A square coil of side 10cm has 10 turns. It rotates in a magnetic field of induction 0.02T and produces a maximum induced emf of 10mV. The angular velocity of coil is
7) A metallic rod of length 2m is moved with a velocity of 4m/s in a direction perpendicular to its length and perpendicular to magnetic field of induction 0.3T. The induced emf is
8) The normal flux passing through a coil changes according to the equation $\emptyset = 5t^2 + 2t + 1$, the value of induced emf at t=2s is ? $(If\ \emptyset\ is\ in\ milli\ webers)$
9) A coil of wire of area $0.5m^2$ containing 50 turns is placed in a magnetic field of induction 1T. The plane of the coil is parallel to the field. It is rotated through 90° in 0.5s. The average emf induced is
10) A coil of self-inductance 0.5H is connected to 50V battery. The rate of growth of current in the circuit is
11) The rate of growth of current in a coil is $100As^{-1}$. It induces an emf of 1V in the coil, the self-inductance is
12) The energy stored in a coil of inductance 100mH on passing 2A of current is
13) Calculate the mutual inductance between two coils, when a current of 4A changes to 8A in 0.5s and induces an emf of 50mV in the secondary coil
14) A helicopter rises vertically with a speed of $10ms^{-1}$, if helicopter has a length of 10m and the horizontal component of earth's magnetic field is $1.5\ \times\ 10^{-3}\ Wbm^{-2}$. The induced emf between tip of the nose and the tail of the helicopter is
15) A horizontal straight wire 10m long extending along east and west direction is falling at right angles to the horizontal component of the earth magnetic field $0.30\ \times\ 10^{-4} Wbm^{-2}$. If the induced emf is $1.5\ \times\ 10^{-3}$, the velocity of the wire is
16) A coil has an area of $0.05m^2$ and has 800 turns. After placing the coil in the magnetic field of strength $4\ \times\ 10^{-3}\ Wbm^{-2}$ perpendicular to the field, the coil is rotated by 90° in 0.1s. The average emf induced is
17) A metal conductor of length 1m rotates vertically about one of its ends with an angular velocity of $5\ rad\ s^{-1}$.If the horizontal component of the earth magnetic field is $0.2 \times 10^{-4}T$, then the emf developed between the two ends of conductor is
18) When the current changes from +2A to -2A in 0.05s an emf of 8V is induced in the coil, the coefficient of self-induction of the coil is

VII. Problems (Level – II)

1) The magnetic field in a certain region is given by $\vec{B}\ = (40\,\vec{\imath}\ -\ 18\vec{k})\ gauss$. How much flux passes through a loop of area 50 cm^2 in this region if the loop lies flat in the X-Y plane.
2) An inductor coil stores 32J magnetic energy and dissipates it as heat at the rate of 320W, when a current of 4A is passed through it. The time constant of circuit is
3) An uniformly wound solenoid of inductance $18 \times 10^{-4}H$ and resistance 6Ω is broken into two identical parts, these identical coils are then connected in parallel across a 15V battery of negligible resistance, the time constant of circuit is

4) Calculate the inductance of an air core solenoid containing 300 turns if the length of solenoid is 25.0cm and its cross-sectional area is 4.00cm^2.
5) The magnetic flux threading a metal ring varies with time t according to $\phi_B = 3(at^3 - bt^2)\ Tm^2$ with a=2.00S^{-3} and b=6.00S^{-2}, the resistance of the ring is 3Ω. Determine the maximum current induced in the ring during the interval from t=0 to t=2s
6) When two self-inductance coils 4mH and 8mH are joined in series and parallel, find the effective self-inductance values
7) If the flux linked with a coil changes by 10%, by what percentage does the energy stored in the coil change?
8) A long solenoid of length 1m cross sectional area $10cm^2$ having 1000 turns has a small coil with 20 turns at its centre. The mutual inductance of two circuits is
9) Two solenoids of an equal number of turns have their lengths and radii in the same ratio. What is the ratio of their self-inductance?
10) A horizontal straight wire 10m long extending from east to west is falling with a speed of $5ms^{-1}$ at right angles to the horizontal component of earth's magnetic field $0.30 \times 10^{-4}Wbm^{-2}$
    a) What is the instantaneous value of the emf induced in the wire?
    b) What is the direction of emf?
11) A jet plane is travelling towards west at a speed of 1800 km/h. What is the voltage difference developed between the ends of the wing having a span of 25m? If the Earth's magnetic field at the location has magnitude $5 \times 10^{-4}T$ and the dip angle is 30°.
12) We are rotating a 1m long metallic rod with an angular frequency of 400 $rad\ s^{-1}$ with an axis normal to the rod passing through its one end and on the other end of the rod a circular metallic ring is connected. There exists a uniform magnetic field of 0.5T, which is parallel to axis everywhere. Find out the emf induced between the centre and the ring.
13) A long solenoid with 15 turns per cm has a small loop of area $2cm^2$ placed inside the solenoid normal to its axis. If the current carried by solenoid changes steadily from 2A to 4A in 0.1s. What is the induced emf in the loop while the current is changing?
14) A square of side L meters lies in the X-Y plane in a region where the magnetic field is given by $B = B_0\ (2\vec{i} + 3\vec{j} + 4\vec{k})T$ where B_0 is constant , the magnitude of flux passing through the square is
15) Kamala pedals a stationary bicycle whose pedals are attached to a 100-turn coil of area 0.10m^2. The coil rotates at half revolution per second and it is placed in a uniform magnetic field of 0.01 T perpendicular to the axis of rotation of the coil. What is the maximum voltage generated in the coil?

VIII. Each of these questions contains two statements, Statement 1 – Assertion and Statement 2 – Reason. Each of these questions also has four alternative choices, out of which only one is a correct answer. You have to select one of the codes ‘a’, ‘b’, ‘c’, ‘d’ given below

a – Statement 1 is true. Statement 2 is true and is the correct explanation for Statement I.

b – Statement 1 is true. Statement 2 is true, but is not the correct explanation for Statement I.

c – Statement 1 is true. Statement 2 is false.

d – Statement 1 is false. Statement 2 is true.

1) **Statement 1:** The mutual inductance of two coils doubles if the self-inductance of primary or secondary coil is doubled.
   Statement 2: Mutual inductance is proportional to the self-inductance of primary and secondary coils

2) **Statement 1:** The energy stored in the inductor 2H when a current of 10A flows through it is 100J.
   Statement 2: Energy stored in an inductor is directly proportional to its inductance

3) **Statement 1:** An artificial satellite with a metal surface is moving about the earth in a circular orbit. A current is induced when the plane of the orbit is inclined to the plane of the equator.
   Statement 2: The satellite cuts the magnetic field of earth

4) **Statement 1:** A direct current flows in a closed loop made of soft iron wire. This closed wire will acquire a circular shape.
   Statement 2: The loop changes it shape or moves in such a manner that the flux linked with the loop is maximum.

5) **Statement 1:** Only change in magnetic flux will maintain an induced current in the coil.
   Statement 2: The presence of large magnetic flux through a coil maintains current in the coil if the circuit is continuous.

6) **Statement 1:** If the current is flowing through a machine of iron, eddy currents are produced.
   Statement 2: change in magnetic flux through an area causes eddy currents.

7) **Statement 1:** When magnetic field is in a direction perpendicular to the given area, magnetic flux linked with it is zero.
   Statement 2: This follows from $\emptyset = BA\cos\theta$ where the symbols have their standard meanings.

8) **Statement 1:** When a bar magnet rapidly moves towards or away from a closed coil of wire, a large emf is induced.
Statement 2: The rate of change of magnetic flux cutting the coil is proportional to the induced emf is the underlying principle.

9) **Statement 1:** Faraday's laws are consequence of the Law of conservation of energy
Statement 2: In a purely resistive A.C. circuit, the current lags behind the emf in phase

10) **Statement 1:** Lenz's law violates the principle of conservation of energy
Statement 2: Induced emf always opposes the change in magnetic flux responsible for its production

11) **Statement 1:** When number of turns in a coil is doubled, coefficient of self-inductance of coil becomes four times
Statement 2: This is because $L \propto n^2$

12) **Statement 1:** In the phenomenon of mutual induction, self-induction of each of the coil persists
Statement 2: Self-induction arises when strength of current in one coil changes, in this case current is changing in both the individual coils.

Answers

I. Very short question and answers:

1) Self-induction is the property of coil by virtue of which it opposes the growth or decay of current.
2) According to Lenz's law the direction of current in loop will be clockwise.
3) Lenz's law: The direction of induced emf or induced current is such that it always opposes the cause that produced it.
4) The magnetic flux linked with any surface is equal to total number of magnetic lines of force passing normally through it. $\emptyset = \vec{B} \cdot \vec{A}$
5) Faraday's law: The induced emf in a closed loop or circuit is directly proportional to the rate of change of magnetic flux linked with the coil. $E = -N \frac{d\emptyset}{dt}$
6) The phenomenon of generation of current or emf by changing the magnetic flux is known as electromagnetic induction.
7) The induced circulating currents produced in a conductor itself due to change in magnetic flux linked with the conductor are called eddy currents.
8) Mutual induction is the phenomenon due to which an emf is induced in a coil when the current flowing through a neighbouring coil changes.
9) The emf induced in a conductor moving in a plane perpendicular to magnetic field is called motional emf.
10) Electromagnetic induction
11) Magnetic flux through a surface is a measure of the number of lines of magnetic field lines passing through the surface.
12) $Weber\ or\ Tm^2$
13) a) When a plane of the surface is perpendicular to the magnetic field.
    a) When a plane of surface is kept parallel to magnetic field.

14) The negative sign implies that the direction of induced emf opposes its cause, the change in magnetic flux.
15) Because they produce heating effect and damping effect.

II. True or False:

1) False

   An electric motor converts electrical energy into mechanical energy.
2) True
3) True

   The field at the centre of long solenoid carrying current will be parallel straight lines.
4) False

   Live wires have red insulation cover whereas earth wire has green insulation cover in domestic circuits.
5) True
6) True

   $\emptyset \propto N, induced\ emf \propto N$
7) True
8) False, Magnetic flux is a scalar quantity
9) False, SI unit of magnetic flux is $Weber\ or\ Tm^2$
10) True
11) True
12) True
13) False, Eddy currents are not generated in PVC pipes.
14) True
15) True

III. Fill up the blanks:

1) Zero
2) magnetic flux
3) motional emf
4) Maxwell
5) magnetic induction effect
6) uniform magnetic field
7) undesirable
8) inductor
9) Self-induction
10) mutual induction
11) AC generator
12) Magnet
13) the relative orientation and position of coil w.r.t each other
14) law of conservation of energy
15) 1Wb = 10^8 Maxwell
16) opposes

IV. Multiple Choice Questions:

1) d	2) a	3) d	4) b	5) b
6) c	7) a	8) b	9) c	10) c
11) b	12) c	13) d	14) c	15) b
16) d	17) c	18) d	19) b	20) c

V. Match the following

1)	i – c	ii – d	iii – a	iv – b
2)	i – b	ii – d	iii – a	iv – c
3)	i – b	ii – c	iii – a	iv – d
4)	i – d	ii – c	iii – b	iv – a
5)	i – b	ii – d	iii – a	iv – c
6)	i – a	ii – c	iii – d	iv – d
7)	i – b	ii – a	iii – c	iv – d
8)	i – d	ii – b	iii – d	iv – a
9)	i – d	ii – c	iii – a	iv – b

VI. Problems (Level – I)

1) $E = L\frac{di}{dt} => L = \frac{E}{\frac{di}{dt}} = \frac{200}{\frac{5}{0.1}} = \frac{200}{50} = 4H.$

2) $E = M\frac{di}{dt} = \frac{d\emptyset}{dt}$

$d\emptyset = Mdi$ = 1.5 × 20 = 30Wb.

3) $U = \frac{1}{2}Li^2$

$1Kwh = 3.6 \times 10^6 J$

$3.6 \times 10^6 = \frac{1}{2} L(200)^2 \Rightarrow L = \frac{3.6 \times 10^6 \times 2}{200 \times 200} = 180H.$

4) $M = \mu_0 n_1 N_2 S = (4\pi \times 10^{-7}) \cdot (\frac{50}{10^{-2}}) \cdot 200 \cdot (4 \times 10^{-4}) = 5 \times 10^{-4} H$

5) $\emptyset = NAB\cos\theta$

$= 1 \cdot \pi(10.5 \times 10^{-2})^2 \cdot 10^{-4} \cos(90^\circ - 30^\circ) = 1.73 \times 10^{-6} Wb$

6) $E_{\max} = NAB\omega$

$10 \times 10^{-3} = 10 \times 10^{-2} \times 0.02 \times \omega \Rightarrow \omega = \frac{10 \times 10^{-3}}{10 \times 10^{-2} \times 0.02} = 5\ rad.s^{-1}$

7) Induced emf $E = Blv$

$= 0.3 \times 4 \times 2$

$= 2.4V$

8) $E = \frac{d\emptyset}{dt} = \frac{d}{dt}(5t^2 + 2t + 1) = 10t + 2$

Induced emf at t=2 is $E_{t=2} = 10(2) + 2 = 22\,mV = 22 \times 10^{-3}V$

9) Average induced emf $E = nAB \frac{d}{dt}(\cos\theta)$

$= 500 \times 0.5 \times 1 \times (\frac{\cos 0^\circ - \cos 90^\circ}{0.5}) = 500V$

10) $E = L\frac{di}{dt}$

$50 = 0.5 \frac{di}{dt} \Rightarrow \frac{di}{dt} = \frac{50}{0.5} = 100As^{-1}$

11) $E = L\frac{di}{dt}$

$1 = L \times 100 \Rightarrow L = \frac{1}{100} = 0.01H$

12) $U = \frac{1}{2}Li^2 = \frac{1}{2} \times 100 \times 10^{-3} \times 2^2 = 0.2J$

13) $E = M\frac{di}{dt}$

$50 \times 10^{-3} = \frac{M(8.0 - 4.0)}{0.5}$

$\Rightarrow M = \frac{50 \times 10^{-3} \times 0.5}{4.0} = 6.25 \times 10^{-3}H$

14) $E = Blv = Hlv = 1.5 \times 10^{-3} \times 10 \times 10 = 0.15\,V$

15) $E = Blv \Rightarrow v = \frac{E}{Bl} = \frac{1.5 \times 10^{-3}}{0.3 \times 10^{-4} \times 10} = 5\,ms^{-1}$

16) $E = \frac{d\emptyset}{dt} = NA\frac{dB}{dt} = 800 \times 0.05 \times \frac{4 \times 10^{-5}}{0.1} = 0.016V$

17) $E = \frac{1}{2}Bl^2\omega$

$= \frac{1}{2} \times (0.2 \times 10^{-4}) \times (1)^2 \times 5$

$= 0.5 \times 10^{-4}\,V = 5 \times 10^{-6}\,V$

$= 50\mu V$

18) $E = -L \frac{di}{dt}$

$8 = -L\left(\frac{-2-2}{0.05}\right)$

$L = \frac{8 \times 0.05}{4} = 0.1H$

VII. Problems (Level – II)

1) As the loop is in XY plane, only z component of the magnetic field is effective

$B = -18\, gauss = -18 \times 10^{-4}\, T$

$A = 5 \times 10^{-4}\, m^2$

$\emptyset = BA \cos 0^\circ = (-18 \times 10^{-4}) \times (5 \times 10^{-4})$

$= -90 \times 10^{-8}\, Wb) = -900nWb$

2) $U = \frac{1}{2}Li^2$

$32 = \frac{1}{2} \times L \times (4)^2 \Rightarrow L = 4H$

$P = i^2R \Rightarrow R = \frac{320}{4^2} = 20\, \Omega$

$t = \frac{L}{R} = \frac{4}{20} = 0.2s$

3) Inductance of each part is $L_1 = L_2 = L/2 = 0.9 \times 10^{-4}H$

Resistance of each part $R_1 = R_2 = R/2 = 3\, \Omega$

Time constant $T = \frac{L_1 \parallel L_2}{R_1 \parallel R_2} = \left(\frac{L_1L_2}{L_1+L_2}\right) \times \left(\frac{R_1+R_2}{R_1R_2}\right)$

$\frac{(1.8\times 10^{-4}\times 0.9\times 10^{-4})}{(1.8\times 10^{-4}+0.9\times 10^{-4})} \times \frac{(6+3)}{(6\times 3)} = 0.3 \times 10^{-4} = 3 \times 10^{-5}s$

4) $L = \frac{\mu_0 N^2 A}{l}$

$= \frac{(4\pi \times 10^{-7}) \cdot (300)^2 \cdot (4.00 \times 10^{-4})}{25.0 \times 10^{-2}} = 1.81 \times 10^{-4}H$

5) $\phi_B = 3(at^3 - bt^2)$

$E = \frac{d\emptyset}{dt} = 9at^2 - 6bt$

Induced current $i = \frac{e}{R} = \frac{9at^2 - 6bt}{3} = 3at^2 - 2bt$

For current to be maximum

$\frac{di}{dt} = 0 \Rightarrow 6at - 2b = 0 \Rightarrow t = \frac{b}{3a}$

At $t = \frac{b}{3a}$ the maximum current

$i_{max} = 3a\left(\frac{b}{3a}\right)^2 - 2b\left(\frac{b}{3a}\right) = -\frac{b^2}{3a}$

Magnitude of $i_{max} = \frac{b^2}{3a} = \frac{6^2}{3\times 2} = 6A$

6) $L_{eff} = L_1 + L_2 = 4 + 8 = 12mH$

In parallel $\frac{1}{L_{eff}} = \frac{1}{L_1} + \frac{1}{L_2} = \frac{1}{4} + \frac{1}{8} = \frac{3}{8}$

$$L_{eff} = \frac{8}{3} = 2\frac{2}{3}\,mH$$

7) $U = \frac{1}{2} Li^2$

$\frac{1}{2}\frac{(Li)^2}{L} = \frac{1}{2}\frac{\phi^2}{L}$

$$E_1 = \frac{{\phi_1}^2}{2L} \; and \; E_2 = \frac{1.21{\phi_1}^2}{2L}$$

Percentage of energy stored = $\frac{E_2 - E_1}{E_1} \times 100 = 0.21 \times 100 = 21\%$

8) $M = \frac{\mu_0 N_p N_s A}{l}$

$$= \frac{(4\pi \times 10^{-7}) \cdot 1000 \cdot 20 \cdot (10 \times 10^{-4})}{1}$$

$$= 8\pi \times 10^{-6} H$$

9) $L = \frac{\mu_0 N^2 \pi r^2}{l}$

$$\frac{L_1}{L_2} = \left(\frac{r_1}{r_2}\right)^2 \frac{l_2}{l_1} = \left(\frac{1}{2}\right)^2 \times \frac{2}{1} = 1:2$$

10) a) $E = Blv = (0.3 \times 10^{-4}) \times 5 \times 10 = 1.5 \times 10^{-3} V$

b) current is flowing from west to east by using Fleming's left-hand thumb rule

11) Vertical component $B_v = B \sin\delta$

$$= 5 \times 10^{-4} \sin 30^\circ = 2.5 \times 10^{-4}\, T$$

Difference between voltage between both the ends $E = B_v l v$

$$= (2.5 \times 10^{-4}) \times (25) \times 1800 \times \frac{5}{18}$$

$$E = 3.123\, V$$

12) $E = Blv = B\left(\frac{l\omega}{2}\right) = \frac{1}{2} B l^2 \omega$

$$= \frac{0.5 \times 1^2 \times 400}{2} = 100V$$

13) $E = \frac{d\phi}{dt} = \frac{d}{dt}(BA) = A\mu_0 n \frac{di}{dt}$

$$= (2 \times 10^{-4}) \times (4\pi \times 10^{-7}) \times 1500 \times \frac{2}{0.1}$$

$$= 7.54 \times 10^{-6}\, V$$

14) $d\emptyset = \vec{B}.\vec{A}$

$\vec{A} = L^2\vec{k}$

$\vec{B} = B_0\,(2\vec{i} + 3\vec{j} + 4\vec{k})T$

$\emptyset = B_0\,(2\vec{i} + 3\vec{j} + 4\vec{k}) \cdot L^2\vec{k} = 4B_0 L^2\, Wb$

15) $E = E_0 \sin \omega t$

$$E_0 = NBA\omega = NBA(2\pi v) = 100 \times 0.01 \times 0.1 \times 2 \times 3.14 \times 0.5 = 0.314V$$

VIII. Statement type questions

1) C	2) B	3) A	4) A	5) C	6) D
7) D	8) B	9) C	10) D	11) A	12) A

*******THE END *******

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10 ALTERNATING CURRENT

Synopsis :

- Alternating voltage is a voltage that varies like a sine function with time. $V=V_M$ sinwt Here V_M => Amplitude of potential difference

- Alternating current is a current varies like a sine function with time
  $i=I_m$ sinwt

- $Irms = \frac{im}{\sqrt{2}}$ = 0.707 I_m

- $Vrms = \frac{Vm}{\sqrt{2}}$ = 0.707 V_m

- A.C. Voltage applied to the pure resistor R voltage and current are in phare with each other. i.e $V=V_m$, sinwt and $I=I_m$ Sinwt

A.C. Voltage ($V=V_m$ sinwt) applied to pure inductor, the current in the inductor lags the voltage by $\frac{\pi}{2}$, i.e. $i=i_m$ Sin (wt- $\frac{\pi}{2}$)

- Inductive Reactance X_L=LW

- A.C. Voltage ($V=V_m$ Sinwt) applied to pure capacitor, the current in the capacitor $i=i_m$ Sin (wt+$\frac{\pi}{2}$)

- Capacitive Reactance $X_c= \frac{1}{cw}$

- Phase relationship between current and voltage in an ac circuit by rotating vectors is called phasors.

- For a series LCR circuit
  Impedance Z= $\sqrt{R^2 + (X_C - X_L)^2}$ and φ= $tan^{-1}\frac{X_C - X_L}{R}$

- Average power loss over a complete cycle
  P=Vi cosφ cosφ – Power Factor

- In a series L.C.R. Circuit Resonant Frequency W= $\frac{1}{\sqrt{LC}}$

  Quality Factor Q= $\frac{WL}{R} = \frac{1}{WCR}$

- Q-Factor indicators the sharpness of Resonance.

- Band width 2ΔW= $\frac{W}{Q}$

- Band with and quality factor are inversely proportional to each other.

- Analogies between Mechanical and electrical Quantities.

Mechanical System	Electrical System
$\frac{dx^2}{dt^2} + w^2 x = 0$	$\frac{d^2 q}{dt^2} + \frac{1}{LC}$ Q=0
Mass (M)	Inductance (L)
Displacement (x)	Charge (q)
Velocity V= $\frac{dx}{dt}$	Current i= $\frac{dq}{dt}$
Mechanical Energy E= $\frac{1}{2}kx^2 + \frac{1}{2}mv^2$	Electrical Energy E= $\frac{q^2}{2c} + \frac{1}{2}Li^2$

- Transformer Ratio = $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

- If the secondary coil has greater number of turns than the primary ($N_S > N_P$) the Voltage is stepped up ($V_S > V_P$)

- If the Secondary coil has less turns than the primary ($N_S < N_P$) a step down transformer.

- Transformer is based on the principal of mutual inductance.

Fill up Blank Questions :

1. Who invented induction motor ______________________
2. Tesla is the S.I unit of ________________ physical quantity.
3. A.C. Voltage applied to a pure resistor average current is ____________
4. R.M.S. (r.m.s) Voltage (V) and peak voltage (V_M) relation V =_________ V_M.

5. A.C. Voltage applied to a pure resistor phase difference between A.C. Voltage and Current ________________

6. S.I. unit of Inductive reactance __________________

7. Inductive reactance is directly proportional to __________ and_________ of the current.

8. In a series L.C.R. Circuit at resonant frequency impedance (Z) __________ and current ________________

9. Q-factor is the ratio of reactance of either __________ or ___________ at the resonant frequency.

10. The series L.C.R. Resonant circuit is called as a ______________ Circuit.

11. In a pure inductor or capacitor circuit power consumed in the circuit is Zero the current is said to be __________________

12. S.I. Unit of self inductance ______________

13. In pure Capacitor _________ leads the __________ by an angle of 90”

True or False Question

1. The source of D.C (Direct Current) is Battery.
2. A.C. Voltage is preferably best compared to D.C. Voltage.
3. Current is Vector.
4. In A.C Voltage, Voltage does not varies with time.
5. True power = Apparent power X power factor.
6. In a pure inductor current lags behind the voltage by quarter cycle.
7. The unit of capacitive reactance is ohm.
8. Induction coil used in Radio and Television circuits.
9. In a series L.C.R. Circuit at resonant frequency current is Minimum.
10. Displacement (x) is analogies to charge (q) in Electrical system.

Very Short Answers Questions

1. Which principle is involved in the working of transformer ?
2. What is meant by wattless current ?
3. In pure inductive CKT phase difference between voltage and current ?
4. Physical quantity that remains unchanged in a transformer ?
5. What is the value of inductive reactance X_L in a D.C. Circuit ?
6. Why is the use of AC Voltage preferred over D.C. Voltage ?
7. A Transformer converts 100 V a.c in to 1000V. calculate the number of turns in the secondary if the primary has 20 turns ?
8. Write the equation of efficiency of transformer ?
9. When does a L.C.R. circuit have a minimum impedance ?
10. A 100 Ω resistor is connected to 220 V. 50 H_Z ac supply, what is the r.m.s. value of current in the circuit ?
11. What is transformer ratio ?

Match the Following

1.

1. A.C Voltage	a. $\frac{1}{2\pi\sqrt{LC}}$
2. A.C. Current	b. $\frac{1}{WCR}$
3. Q-Factor	c. i_m sinwt
4. Resonant Frequency	d. X_L=LW
5. Inductive Reactance	e. V_m sinwt

2.

1. Transformer — a. Henry
2. Magnetic Induction — b. $\cos\emptyset$
3. Power Factor — c. Convent A.C. high to low
4. Inductance — d. VI
5. Power — e. Tesla

3. Analogies

1. Mass (M) — a. Current
2. Velocity — b. Resistance
3. Force — c. Self Inductance
4. Damping Constant — d. Applied Voltage
5. Driving Force — e. Inverse Capacitance

4. Dimensions

1. Impedance — a. T^{-1}
2. R.M.S. Voltage — b. $ML^2\ T^{-3}\ A^{-2}$
3. Q-Factor — c. $ML^2\ T^{-3}\ A^{-1}$
4. Resonant Frequency — d. $ML^2\ T^{-3}\ A^{-2}$
5. Inductive Reactance — e. Dimensionless

5.

1. Faraday's Law — a. $N_S < N_P$
2. Transformer ratio — b. i^2 R
3. Step up — c. $\frac{V_S}{V_P} = \frac{N_S}{N_P}$
4. Step down — d. $N_S > N_P$
5. Joule's Law for heat — e. € = - $\frac{d\emptyset_B}{dt}$

6. Phase Difference

1. A.C. through pure resistor — a. Voltage lags the current by $\frac{\pi}{2}$
2. A.C through on inductor — b. Current is maximum
3. A.C. through pure capacitor — c. $\text{Tan}\,\emptyset = (\frac{X_C - X_L}{R})$
4. A.C. through pure series L.C.R Circuit — d. Voltage and current are in same phase
5. Resonance — e. Current lags the voltage by $\frac{\pi}{-2}$

Multiple Choice Questions
(Level 1)

1. Equation which measurer alternating voltage is

   A) V SinW B) Sint C) V_0 Sinwt D) IR

2. In a transformer alternating current is induced in

   A) Primary Coil B) Secondary Coil C) Iron Core D) Resistor

3. The unit of frequency is

   A) Cycle B) Cycle-Second C) Hertz/Second D) Hertz

4. A Current is set to be alternating when it changes in

   A) Magnitude only B) Direction only C) Both Magnitude and direction

   D) None of these

5. For a purely resistive circuit the following statement is correct

   A) Workdone is Zero B) Power consumed is Zero

   c) Heat produced is Zero D)Power factor is unity

6. Magnitude of current at resonance in R-L-C Circuit

   A) Depends upon the Magnitude of R

   B) Depends upon the Magnitude of L

   C) Depends upon the Magnitude of C

   D) Depends upon the Magnitude of R, L and C.

7. The Q-factor of series LCR circuit will increase if

   A) R Increases B) R Decreases

   c) Impedance Increase D) Voltage Increases

8. In a series L.C.R. circuit at resonance

   A) WLC = 1 B) $WL^2\ C^2$ =1 C) W^2LC=1 D) $W^2L^2\ C^2$ =1

9. The power factor of an AC Circuit lies between

   A) 0 and 1 B) -1 and 1 C) 0 and -1 D) None of these

10. If the supply frequency of a transformer increases, the secondary output voltage of the transformer.

    A) Increase B) Decrease C) Remain the Same

    E) None of These

11. The peak voltage of an A.C. Supply is 300V. What is the rms voltage ?

    A) 180 B) 200 C) 212 D) 300 V

12. Calculate the resonant frequency W_r of a series L.C.R. circuit with L=2H and C=32 μF.

    A) 115 rad/s B) 125 rad/s C) 110 r/s D) 135 rad/s

13. A right bulb is rated at 100 w for a 220v supply. Find the resistance of the bulb ?

    A) 424Ω B) 448Ω C) 484Ω D) 524Ω

14. Lamination of transformer core is made of

    A) Cast iron B) Silicon Steel C) Aluminium D) Cast Steel

15. A Transformer cannot raise or lower the voltage of a D.C. supply because

A) There is no need to change the D.C. Voltage

B) A D.C circuit has more losses

C) Faraday's law of electromagnetic induction are not valid since the rate of change of flux is zero

D) None of the above.

16. The transformer oil should have ___ Volatility and_____ viscosity

A) Low, Low B) High, High C) Low, high D) High, Low

17. In a series LCR Circuit with L=2H and C=32 μF and R=10 Ω. What is the Q-Value of circuit ?

A) 35 B) 25 C) 45 D) 15

Multiple Choice Questions
(Level II)

1. A Voltmeter reads V Volts in an A.C Circuit. Then V is

A) Peak value of voltage B) Peak value of current

C) r.m.s. value of current D) r.m.s. value of voltage

2. The displacement in newton's law corresponds to

A) Electromotive force B) Current

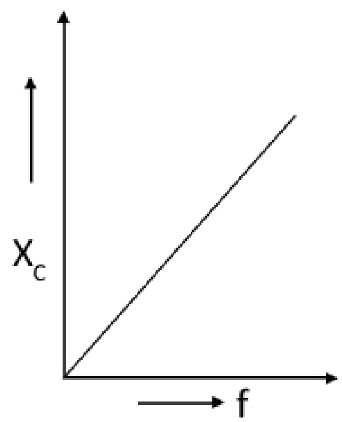
C) Charge D) Rate of change of current

3. If L and R represents inductance and Resistance respectively, then Dimension of L/R will be

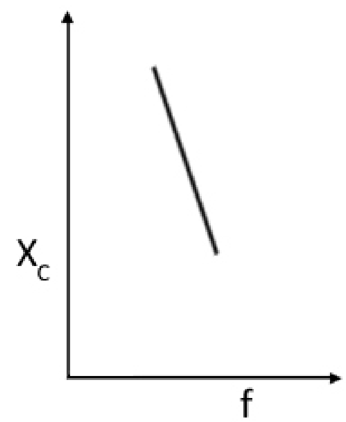
A) ML^OT^O B) $M^0 L^0T$ C) $M^0 L^0T^{-2}$ C) $M^O LT^{-2}$

4. Which of the following curves correctly represent the variation of capacitative reactance (X_c) with frequency (f)

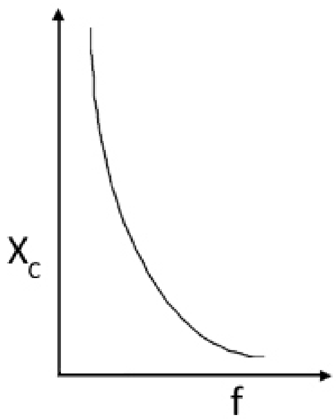
A)



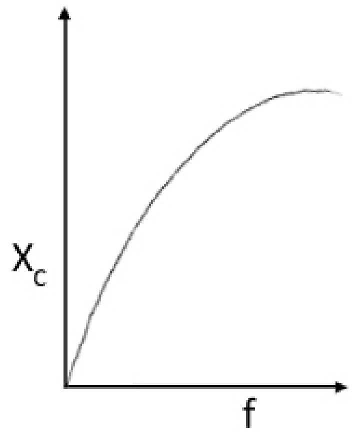
B)



C)



D)



5. A step-up transformer has transformation ratio of 3:2 what is the voltage in secondary, if voltage in primary is 30 V ?

   A) 45 V B) 15V C) 90V D) 300V

6. Reactance of a capacitor of $\frac{1}{\pi}$farad at 50 HZ is

   A) 100 Ω B) 10 Ω C) 50 Ω D) 10^{-2} Ω

7. Resonant frequency of a circuit is f. if the capacitance is made 4 times the initial vale, then the resonant frequency will be come

   A) $\frac{f}{2}$ B) 2f C) f D) $\frac{f}{4}$

8. Which quantity is increased in step-down transformer ?

   A) Current B) Voltage C) Power D) Frequency

9. The Current flowing in a step down transformer 220V to 22V having impedance 220 Ω is

   A) 1A B) 0.1 A C) 1mA D) 0.1 Ma

10. A sinusoidal voltage E=200 Sin 314t is applied to a resister of 10 Ω resistance. Calculate power dissipated heat in watt ?

A) 1000 W   B) 1500 W   C) 1700 W   D) 2000 W

11. The ratio of number of turns in primary and secondary coils of a trans former is 1:20. The ratio of currents in primary and secondary coils will be

A) 1:20   B) 20:1   C) 1:400   D) 400:1

PROBLEMS

1. A 60 μF capacitor is connected to a 110V, 60 Hz ac supply. Determine the r.m.s value of the current in the CKT

   (Ans ; X_C=44.23Ω ; I_{ms}= 2.449 A)

2. Find the power consumed in a circuit having a resistance of 30 ohm in series with an inductance of 0 ohm in series with an a.c with peak current of 1 ampere and peak Voltage of 220 volt.

   (Ans ; Z=50 ohm ; Cosφ=0.6 ; P=66 watt)

3. A Transformer is having 2100 turns in primary and 4200 turns in secondary. An a.c. source of 120, 10 A is connected to it's primary. The secondary voltage and current are

   (Ans ; 240 V ; 5A)

4. A 12 Ω resistor and 0.21 henry inductor are connected to series a.c. source operating at 20 Vott 50 cycle. The phase angle between the current and source voltage is

   (And ; Tanφ = $\frac{X_L}{R}$ = $\frac{WL}{R}$ φ=80^0)

5. An e.m.f of 15 v is applied in a circuit coil containing 5 henry inductance and 10 ohm resistance. The ration of currents at time T= ∞ and t=1 second is (Ans i=i_0(1- $e^{-\frac{R}{L}t}$) => $\frac{i_0}{i}$= $\frac{e^2}{e^2-1}$)

6. What will be the phase difference between virtual voltage and virtual current, when the current in the circuit is Watllers ?

   (Ans = 90^o)

7. An alternating potential $V=V_0 \sin wt$ is applied across a circuit. As a result the current $i=i_0 \sin(wt-\frac{\pi}{2})$ flows in it. The power consumed in the circuit per cycle

(Ans ; $P = Vi \cos\varphi = VI \cos 90^0 = 0$)

ANSWERS

Fill up the Blanks

1. Tesla
2. Magnetic Induction
3. Zero
4. 0.707
5. Same Phase
6. Ohm
7. Inductance, Frequency
8. Minimum, Maximum
9. Inductance, Capacitance
10. Acceptor
11. Wattless
12. Henry
13. Current, Voltage

True or False

1. True	2. True	3. False
4. False	5. True	6. True
7. True	8. True	9. False
10. True		

Very Short Answers Questions

1. Mutual Inductance
2. Average power consumed in the circuit due to component of current is Zero
3. 90^0
4. Frequency
5. 0
6. In A.C. Power losses minimum than D.C
7. . $\frac{V_S}{V_P} = \frac{N_S}{N_P}$ => $N_S = \frac{1000}{100}$ x 20 = 200
8. M= $\frac{Output\ power}{input\ power}$x 100
9. At Resonant Frequency
10. $I_{rms} = \frac{V_{rms}}{R} = \frac{220}{100}$ = 2.2 A
11. $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

Matchings

1)	1. E	2. C	3. B	4. A	5. D
2)	1. C	2. E	3. B	4. A	5. D
3)	1. C	2. A	3. E	4. B	5. D
4)	1. D	2. C	3. E	4. A	5. B
5)	1. E	2. C	3. D	4. A	5. B
6)	1. D	2. E	3. A	4. C	5. B

Multiple Choice Question (Level I)

1) C	2) B	3) D	4) C	5) D	6) A
7) A	8) C	9) A	10) C	11) C	12) B
13) C	14) B	15) C	16) A	17) B	

Multiple Choice Question (Level II)

1) D	2) C	3) B	4) C	5) A	6) D
7) A	8) A	9) B	10) D	11) B	

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11. Electromagnetic Waves

Synopsis:

Electromagnetic Waves:

Electromagnetic waves are those waves in which electric and magnetic fields are perpendicular to each other and each field is perpendicular to direction of propagation of the wave.

Maxwell's theory predicted that electromagnetic waves of all frequencies propagate in vacuum with a speed given by $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$.

Where magnetic permeability $\mu_0 = 4\pi \times 10^{-7}\ H/m$

electric permeability $\epsilon_0 = 8.85 \times 10^{-12}\ C^2 N^{-1} m^{-2}$

According to Maxwell the displacement current

$$i_d = \epsilon_0 \frac{d\phi_E}{dt}$$

Maxwell's Equations:

Maxwell in 1862 formulated the basic laws of electricity and magnetism in the form of four fundamental equations now known as Maxwell's equations.

1. $\oint \vec{E}.\vec{ds} = \frac{q}{\epsilon_0}$ — *Gauss's Law of Electricity*
2. $\oint \vec{B}.\vec{ds} = 0$ — *Gauss's Law of Magnetism*
3. $\oint \vec{E}.\vec{dl} = -\frac{d\phi_B}{dt}$ — *Faraday's Law*
4. $\oint \vec{B}.\vec{dl} = \mu_0 \left(i + \epsilon_0 \frac{d\phi_E}{dt}\right)$ — *Ampere's Law*

Properties of Electromagnetic Waves:

1. If the electromagnetic wave is travelling along the positive direction of the X-axis, the electric field is oscillating parallel to Y-axis and the magnetic field is oscillating parallel to the Z-axis, then

$$E = E_0 \sin(\kappa x - \omega t)$$

$$B = B_0 \sin(\kappa x - \omega t)$$

E_0, B_0 are the amplitudes of the fields

2. $c = \frac{E_0}{B_0} = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8\ m/s$ = speed of light in vacuum.
3. The rate of flow of energy in an electromagnetic wave is described by the vector $\vec{S}$ which is called poynting vector and is expressed as

$$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$$

4. The SI unit of poynting vector $\vec{S}$ is $JS^{-1}m^{-2}$ or Wm^{-2}.
5. The time average of S over one cycle is known as the wave intensity

$$I = S_{\text{avg}} = \frac{E_0 B_0}{2\mu_0} = \frac{{E_0}^2}{2\mu_0 c} = \frac{c{B_0}^2}{2\mu_0}$$

6. The total average energy per unit volume is

$$U = U_{\text{E}} + U_{\text{B}} = \frac{\epsilon_0 \, {E_0}^2}{2} = \frac{{B_0}^2}{2\mu_0}$$

Spectrum of Electromagnetic Waves:

S.No	Name	Wavelength	Frequency (Hz)	Production	Detection
1	Radio waves	> 0.1 m	10^4 *to* 10^8	Rapid acceleration and deceleration of electrons in aerials	Receiver aerials
2	Micro waves	0.1m to 1mm	10^9 *to* 10^{12}	Klystron valve or Magnetron valve	Point contact diodes
3	Infrared	1mm to 700nm	10^{11} *to* 5×10^{14}	Vibration of atoms and molecules	Thermopiles, Bolometer, Infrared Photographic film
4	Visible light	700nm to 400nm	4×10^{14} *to* 7×10^{14}	Electrons in atoms emit visible light when they move from one energy level to a lower energy level	The eye, Photocells, Photographic film
5	Ultra Violet	400nm to 1nm	10^{15} *to* 10^{17}	Inner shell electrons in atoms moving from one energy level to a lower level	Photocells, Photographic film
6	X-rays	1nm to 0.001nm	10^{18} *to* 10^{20}	X-ray tubes or Inner shell electrons	Photographic film, Geiger tubes, Ionisation chambers
7	γ - rays	< 0.001nm	10^{19} *to* 10^{24}	Radioactive decay of the nucleus	Photographic film, Geiger tubes, Ionisation chambers

Applications of Electromagnetic Spectrum:

The different regions of the total electromagnetic spectrum have been put to the following uses

1. Radio waves are used in radar and radio broadcasting.
2. Micro waves are used in long distance wireless communication via satellites.
3. Infrared, Visible and Ultraviolet radiations are used to know structure of molecules.
4. Diffraction of X-rays by crystals gives the details of crystals.
5. The bones are opaque to X-rays but flesh is transparent. Thus X-rays picture of a human body can be used in medical diagnosis of fractures and cracks in bones.
6. The γ – rays are used in the structure of the nuclei of atoms.

Additional points:

- The cosmic rays wavelength is in between 10^{-13}m to 10^{-17}m, α-particles and β-particles present in space are not electromagnetic waves but they are charged particles.

I. Very short question and answers:

1) What is wavelength of gamma rays?
2) Give one use of X-rays
3) How to produce microwaves?
4) What is the principle of production of electromagnetic waves?
5) What is the ratio of speed of X-rays and Microwaves?
6) What is the relation between the amplitudes of the electric and magnetic fields in free space for an electromagnetic wave?
7) The charging current for a capacitor is 0.6 A. What is the displacement current across its plates?

II. Answer True or False

1) Hertz experimentally demonstrated the existence of electromagnetic waves.
2) Maxwell showed the changing electric field does not produce a magnetic field.
3) Electromagnetic waves are those waves in which electric and magnetic fields vary sinusoidal in space and with time.
4) Blue light has higher frequency than X-rays.
5) The sun radiation is most intense in the infrared region.
6) Gamma rays can be produced in transitions of an atomic nucleus from one state to another.
7) Visible light is often emitted when vacancy electrons change their state.
8) Light waves require no medium for their propagation.
9) Speed of electromagnetic waves in free space is $c = \sqrt{\frac{\mu_0}{\epsilon_0}}$.
10) The total average energy per unit volume is $\frac{B^2}{2\mu_0}$.

III. Fill Up the Blanks

1) Electric and magnetic fields in an Electromagnetic wave are_______________to each other.
2) Electromagnetic waves have same___________while travelling in vacuum.
3) In electromagnetic waves, the phase difference between electric and magnetic field vectors are _____________.
4) The quantity $\sqrt{\mu_0 \epsilon_0}$ represents_____________.
5) From Maxwell's hypothesis, a changing electric field gives rise to______________.
6) The structure of solids is investigated by using______________.
7) The radiations used in treatment of muscle ache are_________________.
8) The conduction current is same as displacement current when the source is____________.
9) The ultrahigh frequency band of radio waves in the electromagnetic waves are used as in ___________.
10) Electromagnetic waves possess both____________and_______________.
11) Electromagnetic waves produced by bombardment of high energy electrons on a metal target are?________________.
12) Electromagnetic waves used in RADAR are____________.

13) Electromagnetic waves are produced by____________electric charge.

IV. Multiple Choice Questions:

1) Which of the following has minimum wavelength?

 a) Blue light b) gamma(γ) rays c) Infrared rays d) Microwaves

2) Which of the following has maximum penetration power?
 a) Ultraviolet radiations b) Microwaves c) gamma(γ) rays d) Radio waves
3) Which of the following is called heat radiation?
 a) X-rays b) gamma(γ) rays c) Infrared wave d) Radio waves
4) Electromagnetic waves are transverse in nature is evident by?
 a) Polarisation b) Interference c) Reflection d) Diffraction
5) Which of the following are not electromagnetic waves?
 a) Cosmic rays b) gamma(γ) rays c) β-rays d) X-rays
6) 10cm is a wavelength corresponding to which spectrum?
 a) Infrared rays b) Ultraviolet rays c) Microwaves d) X-rays
7) The correct order of speed of γ-rays, X-rays and microwaves given by v_g, v_x, v_m is
 a) $v_g > v_x > v_m$ b) $v_g < v_x < v_m$ c) $v_g = v_x = v_m$ d) $v_g > v_x < v_m$
8) Maxwell in his famous equations of electromagnetism introduced the concept of
 a) AC b) Displacement current c) Impedance d) Reactance
9) An electromagnetic wave is produced when charge is
 a) Moving with constant velocity c) Falling in an electric field
 b) Moving in a circular orbit d) both b and c
10) Which of the following have zero average value in a plane electromagnetic wave?
 a) Both electric and magnetic fields b) Magnetic field only
 b) Electric field only d) None of these
11) A charged particle oscillates about its mean equilibrium position with frequency of $10^9 Hz$. The frequency of electromagnetic waves produced by the oscillator is
 a) $10^6 Hz$ b) $10^7 Hz$ c) $10^8 Hz$ d) $10^9 Hz$
12) The waves used by artificial satellites for communication is
 a) Microwaves b) infrared waves c) radio waves d) X-rays
13) Which of the electromagnetic waves are used in medicine to destroy cancer cells?
 a) Infrared waves b) Visible rays c) γ-rays d) Ultraviolet rays
14) The direction of propagation of electromagnetic wave is along
 a) E b) B c) B × E d) E × B
15) A plane electromagnetic wave propagating along X-direction can have following pairs of E and B
 a) E_x, B_y b) E_y, B_z c) B_x, E_y d) None of these
16) Name of EM radiations used for detecting fake currency notes
 a) IR b) Microwaves c) UV rays d) γ-rays
17) An electromagnetic wave going through vacuum is described by $E = E_0 \sin(\kappa x - \omega t)$, $B = B_0 \sin(\kappa x - \omega t)$, Then _____________
 a) $E_0\kappa = B_0\omega$ b) $E_0\omega = B_0\kappa$ c) $E_0 B_0 = \omega\kappa$ d) None of these

V. Match the following:

1)

i. $\oint \vec{B}.\overrightarrow{dA}$	a. $\frac{q}{\epsilon_0}$
ii. $\oint \vec{E}.\overrightarrow{dA}$	b. 0
iii. $\oint \vec{E}.\vec{dl}$	c. $\mu_0\ (i_e + \epsilon_0 \frac{d\emptyset_E}{dt})$
iv. $\oint \vec{B}.\vec{dl}$	d. $-\frac{d\emptyset_B}{dt}$

2)

i. E_x	a. $\frac{1}{\sqrt{\mu G}}$
ii. B_y	b. $\frac{1}{\sqrt{\mu_0 G_0}}$
iii. c	c. $\frac{2\pi}{\square}$
iv. κ	d. $E_0 \sin(\kappa z - \omega t)$
v. υ	e. $B_0 \sin(\kappa z - \omega t)$

3)

i. Gauss's law for electricity	a. $\oint \vec{B}.\overrightarrow{dA} = 0$
ii. Faraday's law	b. $\oint \vec{B}.\vec{dl} = \mu_0\ (i_e + \epsilon_0 \frac{d\emptyset_E}{dt})$
iii. Ampere – Maxwell law	c. $\oint \vec{E}.\overrightarrow{dA} = \frac{q}{\epsilon_0}$
iv. Gauss's law for magnetism	d. $-\frac{d\emptyset_B}{dt} = \oint \vec{E}.\vec{dl}$

4)

i. Radio waves	a. < 0.001 nm
ii. Infra-red	b. 1 nm to 0.001 nm
iii. Light	c. 400 nm to 1 nm
iv. X-rays	d. 700 nm to 400 nm
v. γ rays	e. 1 mm to 700 nm
vi. Microwaves	f. 0.1 m to 1 mm
vii. Ultraviolet	g. > 0.1 m

5)

i. Ultraviolet	a. Receivers aerials
ii. Microwaves	b. Thermopiles
iii. X-rays	c. Point contact diodes
iv. Light	d. Photographic films
v. Infra-red	e. Eye
vi. Radio waves	f. Geiger tubes
vii. γ rays	g. Ionisation chamber

6)

i. Klystron valve	a. Infra-red
ii. Vibration of atoms and molecules	b. Microwaves
iii. Rapid acceleration and deceleration of electrons in aerials	c. γ rays
iv. X-ray tubes	d. Radio waves
v. Radioactive decay of nucleus	e. X-rays

VI. Problems (Level – I)

1) The magnetic field in a plane electromagnetic wave given by $B_y = (2 \times 10^{-7}T)\ \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ is
2) The potential difference between the plates of a parallel plate capacitor is charging at the rate of 10^6 Vs^{-1}. If the capacitance is 2μF, what is the value of displacement current in the dielectric of the capacitor?
3) Instantaneous displacement current 1.0A in the space between parallel plates of a 1μF capacitor, can be established by a potential difference of?
4) The magnetic field between the plates of radius 12cm, separated by a distance of 4mm of parallel plate capacitor of capacitance 100 μF along the axis of plates having conduction current of 0.15A is?
5) In an apparatus, the electric field was found to oscillate with an amplitude of $18Vm^{-1}$. The magnitude of oscillating magnetic field will be?
6) The sun delivers 10^4 Wm^{-2} of electromagnetic flux to the earth's surface. The total power that is incident on a roof of dimensions (10m * 10m) will be?
7) The magnetic field at a point between the plates of a capacitor at a perpendicular distance R from the axis of the capacitor plate of radius R, having a displacement current i_d is given by?
8) The rms value of the electric field of light coming from sun is 720 NC^{-1}. The average total energy density of the electromagnetic wave is?
9) A plane electromagnetic wave of frequency 25MHz travels in free space along the x-direction. At particular point in space and time E = 6.3 $\vec{J}$ V/m. What is B at this point?
10) A radio can tune any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?
11) The amplitude of the magnetic field part of harmonic electromagnetic wave in vacuum is B_0 = 510 nT. What is the amplitude of the electric field part of the wave?

VII. Problems (Level – II)

1) Suppose that the electric field amplitude of an electromagnetic wave is E_0 = 120 N/C and that its frequency is ν = 50.0 MHz. Find expressions for E and B.
2) The magnetic field in a plane electromagnetic wave is given by $B_y = (2 \times 10^{-7}T)\ \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$. Write the expression for electric field.
3) Light with energy flux of 18 W/cm^2 is falls on a non-reflecting surface at normal incidence. If the surface has an area of $20cm^2$. Find the average force exerted on the surface during a 30-minute span.
4) Suppose that the electric field part of an electromagnetic wave in vacuum is E = 3.1 cos (1.8 y + 1.5 * 10^6 t) (missing I bar). Write the expression for the magnetic field part of the wave.
5) About 5% of the power of a 100 W light bulb is converted to visible radiation. What is the average intensity of visible radiation at a distance of 10 m?
6) An electromagnetic wave of frequency ν = 3.0 MHz passes from vacuum into a dielectric medium with permittivity ϵ = 4.0, then find wavelength and frequency.

VIII. Each of these questions contains two statements, Statement 1 – Assertion and Statement 2 – Reason. Each of these questions also has four alternative choices, out of which only one is a correct answer. You have to select one of the codes ‘a’, ‘b’, ‘c’, ‘d’ given below

a – Statement 1 is true. Statement 2 is true and is the correct explanation for Statement I.

b – Statement 1 is true. Statement 2 is true, but is not the correct explanation for Statement I.

c – Statement 1 is true. Statement 2 is false.

d – Statement 1 is false. Statement 2 is true.

1) **Statement 1:** Electromagnetic waves exert radiation pressure
   Statement 2: Electromagnetic waves carry energy
2) **Statement 1:** Light is a transverse wave but not an electromagnetic wave
   Statement 2: Maxwell showed that speed of electromagnetic waves is related to the permeability and permittivity of the medium through which it travels.
3) **Statement 1:** For cooking in a microwave oven, food is always kept in a metal container
   Statement 2: The energy of microwave cannot be easily transferred to the food in a metal container
4) **Statement 1:** X-ray astronomy is possible only from satellites orbiting the earth
   Statement 2: Efficiency of a X-ray telescope is high in comparison to other telescope.

Answers

I. Very short question and answers:

1) < 0.001 nm
2) X-rays are used as diagnostic tools in medicine
3) Klystron valve or magnetron valve
4) Accelerated charges produces electrical and magnetic fields
5) 1:1
6) $\frac{E_0}{B_0} = c$
7) $i = i_d = 0.6A$

II. Answer True or False

1) True
2) False (Changing electric fields must produce magnetic field)
3) True
4) False (Blue light has lower frequency than X-rays)
5) True

6) True
7) True
8) True
9) False ($c = \frac{1}{\sqrt{\mu_0 G_0}}$)
10) True

III. Fill Up the Blanks

1) Mutually perpendicular
2) Speed
3) Zero (electric and magnetic field vectors always vary in same phase)
4) Inverse of speed of electromagnetic waves ($c = \frac{1}{\sqrt{\mu_0 G_0}}$)
5) a magnetic field
6) X-rays
7) Infrared radiation
8) Either ac or dc
9) Cellular phone communication
10) Energy, momentum
11) X-rays
12) Microwaves
13) Oscillating

IV. Multiple Choice Questions:

1) B 2) C 3) C 4) A (only transverse wave can be polarised)
5) C (β-rays consists of electron which are not electromagnetic waves)
6) C 7) C (All electromagnetic waves travel with same speed)
8) B 9) D 10) A 11) D 12) A 13) C 14) D 15) B 16) C 17) A

V. Match the following:

1) i – b ii – a iii – d iv – c
2) i – d ii – e iii – b iv – c v - a
3) i – c ii – d iii – b iv – a
4) i – g ii – e iii – d iv – b v - a vi – f vii - c
5) i – d ii – c iii – g iv – e v - b vi – a vii - f
6) i – b ii – a iii – d iv – e v - c

VI. Problems (Level – I)

1) $2.38 \times 10^{10}\ Hz$

$$B = B_0 \sin(\kappa x - \omega t)$$
$$k = \frac{2\pi}{\square} = 0.5 \times 10^3$$
$$\lambda = \frac{2\pi}{0.5 \times 10^3} = 126\ cm$$

$$\omega = 2\pi f = 1.5 \times 10^{11}$$
$$f = \frac{1.5 \times 10^{11}}{2\pi}$$
$$f = 2.38 \times 10^{10} Hz$$

2) $i_d = \frac{\epsilon_0 A}{d} \cdot \frac{dy}{dt} = C \cdot \frac{dy}{dt} = (2 \times 10^{-6}) \times 10^6 = 2A$

3) $\frac{q}{E} = C \cdot \frac{v}{t}$

$i_d = C \cdot \frac{v}{t}$

$\frac{v}{t} = \frac{i_d}{C} = \frac{1}{10^{-6}} = 10^6\ VS^{-1}$

4) $B \propto r$, Since the point is on the axis $r = 0$, $So\ B = 0$.

5) $B_0 = \frac{E_0}{c} = \frac{18}{3 \times 10^8} = 6 \times 10^{-8}\ T$

6) Total Power = solar constant × area

$= 10^4 \times 10 \times 10$

$= 10^6\ W$

7) $\oint \vec{B}.\vec{dl} = \mu_0 i_d$

$B(2\pi R) = \mu_0 i_d$

$B = \frac{\mu_0 i_d}{2\pi R}$

8) Total average energy = $\epsilon_0 E_{rms}^2$

$= 8.85 \times 10^{-12} \times 720^2$

$= 4.58 \times 10^{-6}\ Jm^{-3}$

9) $B = \frac{E}{c} = \frac{6.3}{3 \times 10^8} = 2.1 \times 10^{-8}\ T$

10) $\lambda_1 = \frac{c}{u_1} = \frac{3 \times 10^8}{7.5 \times 10^6} = 40m$

$\lambda_2 = \frac{c}{v_2} = \frac{3 \times 10^8}{12 \times 10^6} = 25m$

The wavelength band is 25m to 40m

11) $E_0 = cB_0 = 3 \times 10^8 \times 510 \times 10^{-9} = 153\ NC^{-1}$

VII. Problems (Level – II)

1) $B_0 = \frac{E_0}{c} = \frac{120}{3 \times 10^8} = 4 \times 10^{-7} = 400nm$

$\omega = 2\pi f = 2\pi \times 50 \times 10^6 = 3.14 \times 10^8\ rad/s$

$k = \frac{\omega}{c} = \frac{3.14 \times 10^8}{3 \times 10^8} = 1.05\ rad/m$

$\lambda = \frac{c}{v} = \frac{3 \times 10^8}{50 \times 10^6} = 6\ m$

$E = E_0 \sin(\kappa x - \omega t)\vec{j} = 120\ \sin(1.05x - 3.14 \times 10^8 t)\vec{j}$

$B = B_0 \sin(\kappa x - \omega t)\vec{k} = 4 \times 10^{-7} \sin(1.05x - 3.14 \times 10^8 t)\vec{k}$

2) $E_0 = B_0 c = (2 \times 10^{-7}) \times (3 \times 10^8) = 60\ V/m$

$E_z = E_0 \sin(\kappa x + \omega t) = 60\ \sin(0.5 \times 10^3\ x + 1.5 \times 10^4 t)\ V/m$

3) Total energy falling on surface is

$U = 18 \times 20 \times 30\ mins = 18 \times 20 \times 30 \times 60 = 6.48 \times 10^5\ J$

Total momentum $P = \frac{U}{c} = \frac{6.48 \times 10^5}{3 \times 10^8} = 2.16 \times 10^{-3}\ kg\ m/s$

Average force $F = \frac{P}{t} = \frac{2.16 \times 10^{-3}}{30 \times 60} = 1.2 \times 10^{-6}\ N$

4) $B_0 = \frac{E_0}{c} = \frac{3.1}{3 \times 10^8} = 1.03 \times 10^{-8}\ T = 10..3nT$

$B = B_0 \cos(\kappa y + \omega t)\ \vec{k} = 10.3\ nT\ \cos(1.8y + 5.4 \times 10^6)\ \vec{k}$

5) $Intensity = \frac{\text{power of visible light}}{\text{area}}$

$$I = \frac{100 \times \frac{5}{100}}{4\pi r^2} = \frac{1 \times \frac{5}{100}}{(4\pi 10)^2} = 4 \times 10^{-3}\ W/m^2$$

6) In vacuum $\epsilon_0 = 1$, in medium $\epsilon = 4$

Refractive index $\mu = \sqrt{\frac{\epsilon}{\epsilon_0}} = \sqrt{\frac{4}{1}} = 2$

Wavelength $\lambda' = \frac{\lambda}{\mu} = \frac{\lambda}{2}$

And wave velocity $v = \frac{c}{\mu} = \frac{c}{2}$

Wave length and velocity becomes half and frequency remains unchanged.

VIII. Each of these questions contains two statements,

1) B
2) D
3) D
4) C

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12. DUAL NATURE OF RADIATION AND MATTER

SYNOPSIS

1. The discovery of x-rays by Roentgen, electron by J. J. Thomson were important milestones in the understanding of atomic structure.
   - At sufficiently low pressure 10^{-2} to 10^{-3} mm of Hg nearly, high voltage (> 10,000V) in a discharge tube, cathode rays are produced. These cathode rays were discovered by William Crookes.
   - The speed and specific charge ($\frac{e}{m}$) of cathode rays were experimentally determined by J. J. Thomson, later he named, cathode rays of particles as electrons.
   - Specific charge of electron ($\frac{e}{m}$) = 1.76×10^{11} c/kg
   - This value is independent of cathode substance (or) gas in discharge tube . These cathode rays (electrons) are fundamental universal constituents of matter.
   - Millikan's oil drop experiment gives charge of an electron. Electric charge is quantised.
   - Charge of an electron (e) = 1.6×10^{-19} C.

2) The some physical processes of the electron emission are

(i) Thermionic emission

(ii) Field emission

(iii) photo-electric emission

The unit of energy commonly used in atomic and nuclear physics is

Electron volt (e V)

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

3) The minimum energy needed by an electron to come out from a metal surface is called 'Work Function (ϕ_0) of the metal.

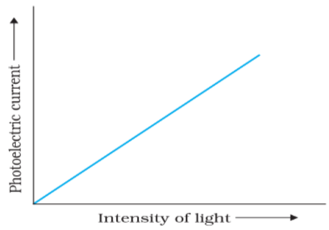
$$\text{Work function } (\phi_0) = h\nu_0 = \frac{hc}{\lambda_0}$$

4) **Photoelectric effect** : When a light of suitable frequency illuminates on a metal surface, electrons are emitted from metal surface. These electrons are known as photo electrons. This photoelectric effect are discovered by Heinrich Hertz.

(i) photo electric effect involves conversion of light energy into electrical energy.

5) The main features of photoelectric effect :

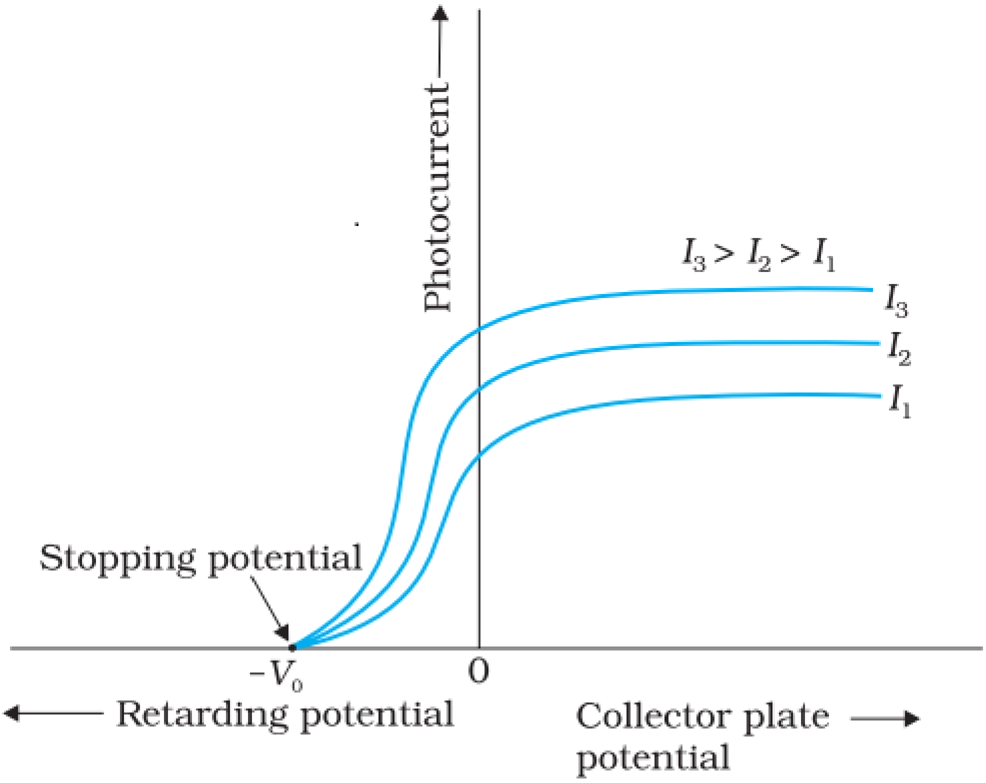
(i) For a frequency (ν) of incident radiation lower than the cut-off (or) threshold frequency (ν_0)no photo electric emission is possible even if the intensity is large.



(ii) The photo current i.e. no of photo electrons emitted per second is directly proportional to the intensity of incident radiation.

(iii) The maximum kinetic energy of photo electrons depends on the frequency of incident radiation and is independent of intensity of incident radiation.

(iv) The minimum negative (retarding) potential V_0 is for which the photo current stops (or) becomes zero is called stopping potential (V_0).



The stopping potential (V_0) is linearly varies with the frequency of incident radiation and is independent of intensity of incident radiation.

(v) The photo electric emission is an instantaneous process without any apparent time lag ($\sim 10^{-9}$ or less).

6) **Einstein's photoelectric Equation :**

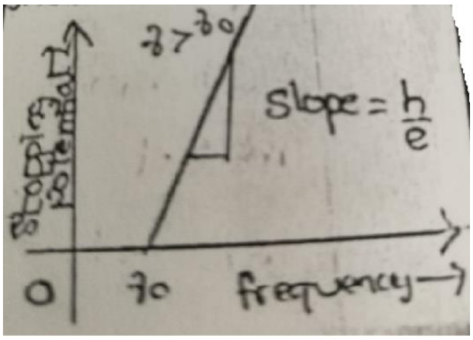
$$h\nu = \phi_0 + K_{max} = h\nu_0 + K_{max}$$

∴ Maximum kinetic energy of photo electrons is $K_{max} = h\nu - h\nu_0$

Where $h\nu$ = energy of incident radiation

$h\nu_0 = \phi_0$ = work function of metal

Millikan proved the validity of Einstein's photoelectric equation.



$K_{max} = eV_o = h\nu - h\nu_0$ for $\nu \geq \nu_0$

$\Rightarrow V_0 = \left(\frac{h}{e}\right)\nu - \frac{h\,\nu_0}{V_0}$ (∴ y = mx + c)

Stopping potential (V_0) versus frequency (ν) curve is a straight line with slope = $\frac{h}{e}$

7) The photon :

(i) Tiny packets (or) quanta of light energy . Its rest mass is zero.

(ii) It shows particle nature of light.

(iii) Photon energy $E = h\nu$ Where C = speed of light

Momentum $P = \frac{h\,\nu}{c} = \frac{h}{\lambda} = \frac{E}{c}$

(iv) photons are electrically neutral and are not deflected by electric and magnetic field.

(v) In a photon –particle collision, the total energy, the total momentum are conserved, but no of photons may not be conserved.

8) Wave nature of Matter :

(i) Light has dual nature (wave –particle). Radiation and matter should be symmetrical in nature. The waves associated with the moving material particles are called 'matter waves' (or) 'de- Broglie waves'.

(ii) The de- Broglie wave length $\lambda = \frac{h}{p} = \frac{h}{mv}$

The de- Broglie wave length (ƛ) is independent of charge and nature of material particle.

(iii) Matter waves are propagate in vaccum hence these are not mechanical waves.

(iv) de – Broglie's matter wave concept supports the Bohr's concept of stationary orbits.

$2\pi r = n\lambda$ where $\lambda = \frac{h}{m\,v}$

$2\pi r = \frac{n\,h}{m\,v} \Rightarrow mvr = \frac{n\,h}{2\pi}$

(v) According to Heisenberg's uncertainty principle , it is not possible to measure both the position and momentum of an electron at the same time exactly.

$\Delta x \,.\, \Delta p \approx \hbar$

(vi) Electron diffraction experiments by Davisson and Germer, and by G. P. Thomson verified and confirmed the wave nature of electron.

Electron microscope works on the phenomena of de- Broglie waves.

9) **Photo –cell :** A photo cell is a technological application of the photo electric effect.

It converts light energy into electrical energy.

Uses : (i) to measure intensity of light

(ii) automatic door opener

(iii) in burglar alarms

(iv) in fire alarms

(v) in industries for detecting minor flaws (or) holes in metal sheets.

PHYSICAL CONSTANTS :

1) Electron charge (e) = 1.6×10^{-19} C
2) Specific charge of an electron ($\frac{e}{m}$) = 1.76×10^{11} C/ kg
3) Mass of electron (m) = 9.1×10^{-31} kg
4) Speed of light (c) = 3×10^{8} m/s
5) 1 electron volt (ev) = 1.6×10^{-19} J
6) Planck's constant (h) = 6.63×10^{-34} J. S
7) Boltzman's constant (kg) = 1.38×10^{-23} J / K

Formulae

1) Work function ($\emptyset_0$) $= h\,v_0 = \frac{h\,c}{\lambda_0}$
2) Maximum kinetic energy = K_{max} $= e\,V_0 = \frac{1}{2} m\,v^2_{max}$
3) $h\,v = \emptyset_0 + K_{max}$ (or) $K_{max} = h\,v - h\,v_0$
4) $K_{max} = hc\,(\frac{1}{\lambda} - \frac{1}{\lambda_0}) = e\,V_0 = \frac{1}{2} m\,v^2_{max}$ $(v \geq v_0)$
5) Speed of light $C = v\,\lambda_0$
6) Energy of photon $E = h\,v = \frac{h\,c}{\lambda_0}$
7) De- Broglie wave length : $\lambda = \frac{h}{p} = \frac{h}{m\,v} = \frac{h}{\sqrt{2\,m\,k}}$

($\therefore$ K = kinetic energy = $\frac{p^2}{2m}$)

8) De- Broglie wave length (λ) associated with charged particle :

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2\,m\,q\,v}}$$ ($\therefore$ w = k = q v , q= charge of particle)

9) λ Electron $= \frac{12.27}{\sqrt{V}}$ A^0 $= \frac{1.227}{\sqrt{V}}$ nm $= \sqrt{\frac{150}{V}}$ A^0

10) λ Proton $= \frac{0.286}{\sqrt{V}}$ A^0

11) De- Broglie wave length of thermal neutron : $\lambda = \frac{h}{\sqrt{3\, mK_B T}}$

Kinetic energy E = $\frac{3}{2}$ K_B T

Where T = absolute temperature

K_B = Boltzman's constant

12) The no of photons emitted per second is

$$N = \frac{P}{E} = \frac{P}{h\,v} = \frac{P\,\lambda}{h\,c}$$

13) Intensity of light (I) = $\frac{E}{A\,t} = \frac{P}{A}$

For a point source I = $\frac{P}{4\,\pi\,r^2}$

For a line source I = $\frac{P}{2\,\pi\,l}$

Fill in the Blanks :

1) When the speed of electrons increase, then the value of its specific charge ______.

2) The maximum kinetic energy of electrons emitted in the photo electric effect is linearly dependent on the _______ of the incident radiation.

3) Hertz experiments to generate and detect electromagnetic waves and Maxwell equations of electromagnetism strongly establish the __________nature of light.

4) Photo electric emission occurs only when the λ of incident light has ________than a certain maximum wave length.

5) The maximum energy of electrons released in a photocell is independent of ______of incident light.

6) In Hertz's experiment on the production of electromagnetic waves by means of spark discharge, high voltage sparks across the detector loop were enhanced when the emitter plate was illuminated by __________light.

7) Radiation and matter should be symmetrical in nature. The waves associated with the moving material particles are called _________

8) In a photon- particle collision __________may not be conserved.

9) According to Einstein's photoelectric equation, the graph between maximum kinetic energy and the frequency of incident radiation is a straight line. The slope of the graph gives _________

10) Electron diffraction experiments by Davisson and Germer, and by G. P. Thomson have verified and confirmed _______

11) According to _______principle, it is not possible to measure both position and momentum of an electron simultaneously.

12) In interaction of radiation with matter, radiation behaves as ______nature.

13) The work- functions of Casium and Platinum are 2.14 eV and 5.65 eV respectively. The ratio of the slope of the stopping potential versus frequency plot for cs to that of pt is __________.

14) Photo cell converts light energy into _______energy

15) In a x-ray tube, electrons accelerated through a potential difference of 15,000 V strike a copper target. The speed of emitted x-rays inside the tube is _____m/s.

II. TRUE OR FALSE

1. Cathode rays are deflected in a magnetic field, moving parallel to the direction of magnetic field.
2. The photo electric emission process is time-delay process.
3. Dual nature of radiation is shown by photo electric effect and diffraction.
4. In interaction of radiation with matter, radiation behaves as wave nature.
5. Photons are deflected by electric and magnetic field.
6. In a photon-particle collision, the total energy , total momentum and the number of photons are conserved.
7. Davisson- Germer experiment proved wave nature of light .
8. When ultraviolet rays incident on a positively (or) negatively charged zinc plate, it emits electrons.
9. Cathode rays do not deflect in electric field.
10. The kinetic energy of photo electrons emitted by a photosensitive surface depends on the intensity of incident radiation.

MATCHINGS

III. 1.

A. William Crookes	1. X- rays
B. J. J. Thomson	2. Cathode rays
C. Heinrich Hertz	3. Specific charge of electron
D. Roentzen	4. Photo electric effect

2.

A. Electromagnetism equations	1. J. J. Thomson
B. Electron	2. G. P. Thomson
C. Detection of electromagnetic waves	3. Maxwell
D. Wave nature of electrons	4. Hertz

3.	A. Thermionic Emission	1. Electric field is applied to the metal surface.
	B. Field emission	2. Striking the fast moving electrons on the metal surface.
	C. Photo electric emission	3. Heat energy is given to the metal surface.
	D. Secondary emission	4. Light of suitable wave length incident on metal surface

4.	A. Work – function	1. $\Delta x \, \Delta p \approx \hbar$
	B. Einstein photo electric equation	2. $\emptyset_0 = \frac{h\,c}{\lambda_0}$
	C. de- Broglie relation	3. $\lambda = \frac{h}{m\,v}$
	D. Heisen berg's uncertainity principle	4. $K_{max} = h\nu - \phi_0$

5.	A. Threshold frequency	1. No of photo electrons emitted per second
	B. Stopping potential	2. Minimum frequency to occur photo electric effect
	C. Saturation current	3. Minimum retarding potential
	D. Photo electric current	4. Maximum number of photo electrons emitted per second

Multiple choice Questions :

1. The specific charge for cathode rays is
   a) Depend upon the material of the cathode.
   b) Depend upon the nature of the gas in the discharge tube
   c) Constant
   d) Variable
   e)
2. A strong argument for the particle nature of cathode rays is that they
   a) Produce fluroscence b) travel through vaccum
   c)cast shadow d) get deflected by electric and magnetic fields
3. Arrange the values of specific charges of the following particles in the Descending order

   1) neutron 2) α - particle 3) proton 4) positron

   a) 4 > 3 > 1 > 2 b) 4 > 3 > 2 > 1 c) 2 > 1 > 3 > 4 d) 2 > 3> 4 >1

4. A particle with rest mass m_0 is moving with speed of light C. The de- Broglie wave length associated with it will be

   a) $\frac{m_0 c}{h}$ b) $\frac{h\,v}{m_0}$ c) zero d) ∞

5. If E_1, E_2, E_3 are the respective kinetic energies of an electron, α -particle and a proton each having the same de-Broglie wave length then

   a) $E_1 > E_2 > E_3$ b) $E_3 > E_2 > E_1$ c) $E_1 > E_3 > E_2$ d) $E_3 > E_1 > E_2$

6. If the kinetic energy of a free electron doubles, its de-Broglie wave length charges by the factor

a) 2 b) $\frac{1}{2}$ c) $\sqrt{2}$ d) $\frac{1}{\sqrt{2}}$

7. A particle of mass m is projected from ground with velocity ' μ ' making angle with the vertical. The de- Broglie wave length of the particle at the highest point is

a) ∞ b) $\frac{h}{m\mu \sin\theta}$ c) $\frac{h}{m\,\mu}$ d) $\frac{h}{m\,\mu\cos\theta}$

8. A particle is dropped from a height H. The de- Broglie wave length of the particle as a function of height is proportional to

a) H b) H ½ c) H^{2} d) $H^{-1/2}$

9. What is the de- Broglie wave length associated with an electron, accelerated through a potential difference of 100 volts ?

a) 0.12 nm b) 1.230 nm c) 0.123 A^{0} d) 1.230 A^{0}

10. An electron , an particle and a proton have same kinetic energy, which of these particles has the shortest de-Broglie wave length ?

a) Electron b) α - particle c) proton d) None

11.When visible light is incident on a metal surface, no photo electrons are emitted, which of the following radiation is selected to occur photo electric effect.

a) Infra red radiation b) micro wave

c) radio waves d) ultraviolet rays

12. Two radiations containing photons of energy are 2 eV and 5 eV, incident successively on the metal surface. The work function of metal is 1 eV. The ratio of the maximum velocities of the emitted electrons in the two cases will be

a) 1 : 3 b) 1 : 4 c) 4 : 1 d) 1 : 2

13. Two identical, photo cathodes receive light of frequencies f $_1$ and f $_2$. If the velocities of the photo electrons (of mass m) coming out are respectively V_1 and V_2, then

a) $V_1 - V_2 = [\frac{2h}{m} (f_1 - f_2)]^{\frac{1}{2}}$ b) $V_1 + V_2 = [\frac{2h}{m} (f_1 - f_2)]^{\frac{1}{2}}$

c) $V_1^2 - V_2^2 = \frac{2h}{m} (f_1 - f_2)$ d) $V_1^2 + V_2^2 = \frac{2h}{m} (f_1 + f_2)$

14. The ratio of momenta of an electron and particle which are accelerated from rest by a potential difference of 100 v is

a) 1 b) $\sqrt{\frac{2\, m_e}{m \propto}}$ c) $\sqrt{\frac{m_e}{m_\alpha}}$ d) $\sqrt{\frac{m_e}{2\, m_\alpha}}$

15. The energy of a photon of green light of wave length 5000 A ^{0} is

a) 5.459 x 10 $^{-19}$ J b) 3.978 x 10 $^{-19}$ J c) 4.132 x 10 $^{-19}$ J d) 3.450 x 10 $^{-19}$J

16. The photo electric current does not depend upon the

(i) frequency of incident light (ii) work function of metal

(iii) stopping potential (iv) intensity of incident light

a) (i) , (iv) only b) (iii) only c) (iii) only d) (i), (iii) only

17. A 2 mw laser operates at a frequency of 6 x 10 14 hz. The no of photons that will be emitted per second is

a) 5×10^{15} b) 2×10^{16} c) 3×10^{16} d) 3×10^{15}

18. The work function of the substance is 4.0 eV. The longest wave length of light that can cause photo electron emission from this substance is approximately.

a) 540nm b) 400 nm c) 310 nm d) 230 nm

19. The maximum kinetic energy of photo electrons emitted from a surface, when photons of energy 6 eve fall on it is 4 eV. The stopping potential in volt is

a) 6 b) 4 c) 2 d) 10

20. If the kinetic energy of particles is increased four times the previous value, the percentage change in the de-Broglie wavelength of the particle.

a) 25 b) 75 c) 60 d) 50

21. If the momentum of the electron is changed by P, then the de- Broglie wave length associated with it charges by 1 %. The initial momentum of the electron will be

a) 100 p b) 200 p c) 400 p d) $\frac{P}{100}$

22. A photo electric surface is illuminated successively by monochromatic light of wave length ƛ and $\frac{ƛ}{3}$. If the maximum kinetic energy of the emitted photo electrons in the second case four times that in the first case, the work function of the photo electric surface is

a) $\frac{h\,c}{\lambda}$ b) $\frac{h\,c}{2\,\lambda}$ c) $\frac{h\,c}{3\,\lambda}$ d) $\frac{h\,c}{4\,\lambda}$

23. When the energy of the incident radiation is increased by 10 % the kinetic energy of photo electrons emitted from a metal surface increased from 0.4 ev to 0.6 ev. The work function of metal is

a) 1.2 eV b) 1.0 eV c) 1.3 eV d) 1.6 eV

24. Consider an electron in a hydrogen atom, revolving in its second excited state

(having radius 4.65 A ^{0}) . The de- Broglie wave length of this electron is

a) 9.7 A^0 b) 6.5 A ^{0} c) 10.7 A ^{0} d) 4.5 A ^{0}

25. A particle A of mass m and initial velocity V collides with a particle B of mass which is at rest. The collision is head on and elastic. The ratio of the de- Broglie wave length after collision is

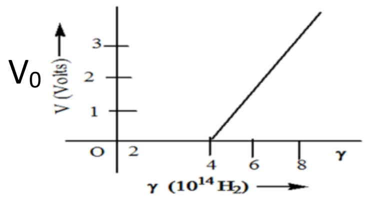
a) $\frac{\lambda_A}{\lambda_B} = 2$ b) $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$ c) $\frac{\lambda_A}{\lambda_B} = 3$ d) $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$

V. DIAGRAM BASED QUESTIONS

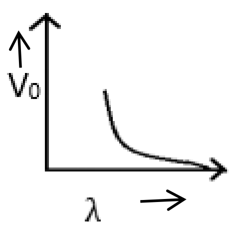
1) The stopping potential (V_0) as a function of frequency (δ) for a Cesium emitter is shown in figure. The work function of Cesium from the figure.

a) 1.82 eV b) 1.66 eV

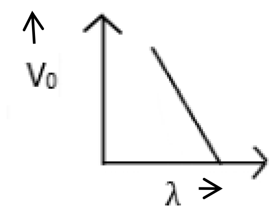
c) 2.12 eV d) 1.95 eV



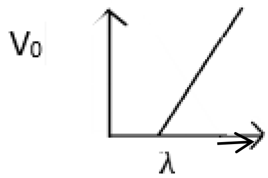
2) Identify the relation between stopping potential (V_0) and photon wave length (λ)

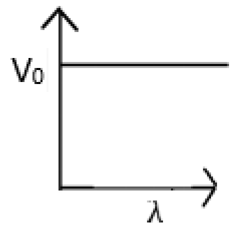


(a)

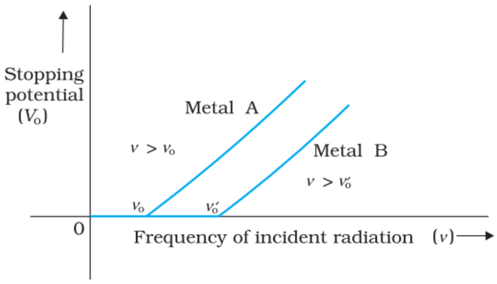


(b)

(c) 

(d) 

3) From the graph it is clear that



(i) the stopping potential varies linearly with the frequency of incident radiation for the given metal.

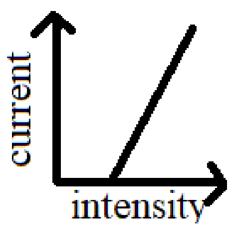
(ii) stopping potential is zero for minimum cut off frequency.

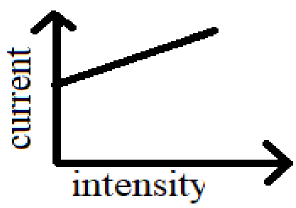
(iii) the work function of metal A is greater than that of the metal B

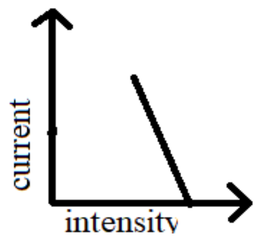
(iv) stopping potential is independent of intensity of incident.

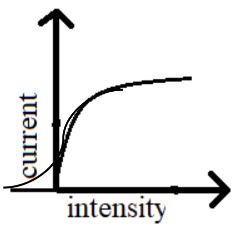
a) (i), (ii) only b) (i), (ii) (iii) only c) (i) , (ii) (iv) d) (iii), (iv)

4) For a given photo sensitive metal, frequency is incident radiation f (f > f0) , the photo electric current varies with the intensity of incident light as

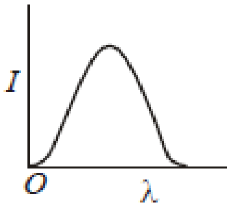
a) 

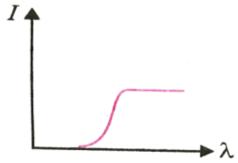
b) 

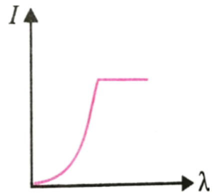
c) 

d) 

5) The anode voltage of a photocell is kept fixed. The wave length (λ) of the light falling on the cathode is gradually charged. The plate current (i) of the photo cell varies as follows :

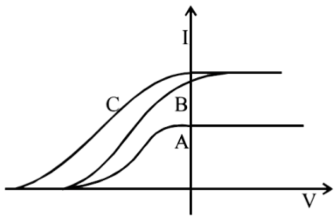
(a) 

(b) 

(c) 

(d) 

6) In a photo electric experiment, Anode potential (v) is plotted against plate current



(i). a) A and B will have different intensities while B and C will have different frequencies.

b) B and C will have same frequency, while A and C will have different frequencies.

c) A and B will have different intensities while A and C will have same frequency

d) A and B will have equal intensities while B and C will have different frequencies.

VI. Assertion and Reason Questions :

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true and R is not correct explanation of A.
c) A is true, R is false
d) A is false, R is true.

1. **Assertion :** Both cathode rays and β particles are electrons . But their origin is different.
   Reason : While cathode rays are of atomic origin, β particles are nuclear origin.

2. **Assertion :** For a fixed incident photon energy, photo electrons have a wide range of energies ranging from zero to maximum value K_{max}.

Reason : Initially, the electrons in the metal are at different energy levels.

3. **Assertion :** The de- Broglie wave length (ƛ) of a photon is $\lambda = \frac{h}{p} = \frac{C}{\delta}$

(C = speed of light)

Reason : Matter waves has dual nature.

4. **Assertion :** The macroscopic material objects do not show wave like properties.

Reason : The wave length of the heavier objects is very small that it is beyond any measurement.

5. **Assertion :** Davisson and Germer Experiment confirms the wave nature of light.

Reason : Matter waves has dual nature.

VII. Very short Answer Questions (VSAQ)

1. What are the constituents of cathode rays ? Who discovered cathode rays ?
2. If the discharge tube is filled with various gases, will the discharge in all gases take place at the same potential difference ? Give reason
3. What is the effect on the velocity of the emitted photo electrons, if the wave length of incident light is decreased ?
4. Which phenomenon established conclusively the particle nature of light ? Name the scientist who has given a theoretical explanation of phenomenon?
5. What is the ratio of the work functions, if threshold wave lengths for two photo metals A and B are λ_A and λ_B ?

6. When a light beam of wave length λ (< λ_0) is incident on metal surface, what is maximum kinetic energy of photo electron emitted in this photo electric emission ?

7. When (i) no of electrons striking the anode in discharge tube is increased
   (ii) the speed of electrons striking the anode are increased ?

8. A metal emits electrons if yellow light falls on it, will it emit electrons with red and green light ?

9. Which experiment, the de- Broglie theoretical relation is experimentally confirmed ?

10. Give examples of photo sensitive substances ? Why are they called so ?

VIII. PROBLEMS (LEVEL – I)

1. The work function of cesium is 2.14 eV. Calculate the threshold frequency of cesium ?
2. Find the minimum wave length of x – rays produced by 30 KV electrons ?
3. The photo electric cut off voltage in a certain experiment is 1.5 V . What is the maximum kinetic energy of photo electrons emitted ?
4. In an experiment on photo electric effect, the slope of the cut off voltage versus frequency of incident light is found to be 4.12×10^{-15} Vs . Calculate the value of Planck's constant ?
5. The work function for a certain metal is 4.2 eV, will this metal give photo electric emission for incident radiation of wave length 330nm ?
6. What is the de Broglie wave length, associated with an electron moving with a speed of 5.4×10^{6} m/s ? ?
7. Calculate the de Broglie wave length of the electrons accelerated through a potential difference of 56 V.

8. What is the de Broglie wave length of an electron with kinetic energy of 120 eV?
9. An electron and a photon each have a wave length of 1.00nm . Find their momenta.
10. The energy flux of sunlight reaching the surface of the earth is 1.388x 10^3 W/m^2. How many photons per square metre are incident on the earth per second. Assume that the photons in the sunlight have an average wave length of 550 nm.

IX. PROBLEMS (LEVEL – II)

1. A metal plate of area 1 x 10^{-4} m^2 is illuminated by a radiation of intensity 16 w/m^2. The work function of the metal is 5 eV. The energy of the incident photons is 10 eV and only 10 % of it produces photo electrons. Calculate the no of emitted photo electrons per second and their maximum energy.

2. A metal surface is illuminated by light of two different wave lengths 248 nm and 310 nm. The maximum speeds of the photo electrons corresponding to these wave lengths are U_1 and U_2 respectively. If the ratio $U_1 : U_2$ = 2 : 1 and hc =1240 e V nm calculate the work function of the metal.

3. A solid sphere of radius 1 cm and work function 4.7ev is suspended from an insulating thread in free space. It is under continuous illumination of 200 nm wave length light. As photo electrons are emitted, the sphere gets charged and acquires potential. Calculate the maximum no of photo electrons emitted from the sphere.

4. The radiation corresponding to 3 → 2 transition of hydrogen atom falls on a metal surface to produce photo electrons. These electrons are made to enter a magnetic field of 3 x 10^{-4} . The radius of largest circular path followed by these electrons is 10mm. Calculate the work function of metal.

5. Two particles move at right angle to each other. The de Broglie wave lengths λ_1 and λ_2 are respectively. The particles suffer perfectly inelastic collision. Calculate the de Broglie wave length λ of the final particle.

6. A particle A of mass m and charge q is accelerated by a potential difference of 50 V. Another particle B of mass 4m and charge q is accelerated by a potential difference of 2500 V. Calculate the ratio of de Broglie wave lengths $\frac{\lambda_A}{\lambda_B}$.

7. If the de Broglie wave length of an electron is equal to 10^{-3} times the wave length of a photon of frequency 6×10^{14} hz . Calculate the speed of electron.

8. An electron in an excited state of Li 2nd ion has angular momentum $\frac{3\,h}{2\,\pi}$. The de Broglie wave length of the electron in this state is þπa_0 (where a_0 is the Bohr radius) What is the value of þ ?

9. The potential energy of a particle varies as

   $U(x) = E_0$ for $0 \le x \le 1$

   $= 0$ for $x > 1$

   For $0 \le x \le 1$, the de Broglie wave length is λ_1 and for $x > 1$, de Broglie wavelength is λ_2 .

   Total energy of the particle is E_0. Find $\frac{\lambda_1}{\lambda_2}$

ANSWERS

I. Fill in the blanks :

1. Decreases
2. Frequency
3. Wave
4. Less
5. Intensity
6.
7. Matter waves (or)de Broglie waves
8. No of photons
9. Planck's constant (h)
10. Wave nature of electrons
11. Heisenberg's uncertainity principle

6. Ultraviolet 12. Particle

13. 1 : 1 14. Electrical 15. 3×10^{3} m/s

II. **True / False**

1. False	2. False	3. True	4. False	5. False
6.False	7. False	8. True	9. False	10. False

III. **Matchings**

1. A → 2	B →3	C →4	D→ 1
2. A → 3	B →1	C →4	D →2
3. A→ 3	B→ 1	C→ 4	D →2
4. A →2	B →4	C →3	D →1
5. A →2	B →3	C →4	D →1

IV. **Multiple Choice Questions :**

1. C	2. D	3. B	4. C	5. C
6. D	7. B	8. D	9. A	10. B
11.D	12. D	13. C	14. D	15. B
16. C	17. A	18. C	19. B	20. D
21. A	22. C	23. D	24. A	25. A

V**. Diagram Based Questions :**

1. b	2. A	3. C	4. A	5. D	6. A

VI. Assertion and Reason Questions :

1. A **2. A** **3.B** **4.A** **5.D**

VII. VSA Q

1. Electrons , William Crookes
2. No, ionisation potential of different gases will be different.
3. $K_{max} = \frac{1}{2} m \vartheta^2 = \frac{h\,c}{\lambda} - \frac{h\,c}{\lambda_0}$

   If λ decreases, the velocity of photo electrons increases

4. Photo electric effect, Albert Einstein
5. $\phi_A = h\,v = \frac{h\,c}{\lambda_A}$; $\phi_B = \frac{h\,c}{\lambda_e}$

$\therefore \frac{\emptyset_A}{\emptyset_E} = \frac{\lambda_B}{\lambda_A}$ → $\phi_A = \phi_e = \lambda_B = \lambda_A$

6. K max = $\frac{h\,c}{\lambda} - \frac{h\,c}{\lambda_0} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$
7. (i) intensity of incident radiation increases
   (ii) Frequency of incident radiation increases

8. $\lambda_{yellow} > \lambda_{green}$

   $\lambda_{yellow} < \lambda_{red}$

   so green light emit electrons

   red light does not emit electrons
9. Electron diffraction experiment by
   Davvison and Germer, and by G. P. Thomson
10. Ex. Li, Na, K, Cs ,Rb
    Some of alkali metals are sensitive even to visible light and gives photoelectric effect.

VIII. PROBLEMS (LEVEL – 1)

1. $\delta_0 = 5.16 \times 10^{14}$ Hz ($\therefore \delta_0 = \frac{\emptyset_0}{h}$)
2. $\lambda_{min} = 0.041 \times 10^{-9}$ m = 0.041nm ($\therefore \lambda_{min} = \frac{h\,c}{e\,V}$)
3. Maximum K. E. = e V_0 = e x 1.5 V = 1.5 e V
4. h = 6.592×10^{-34} J s ($\therefore$ slope $= \frac{h}{e}$)
5. No, since $E < \phi_0$ ($\therefore E = \frac{h\,c}{\lambda} = 6.018 \times 10^{-19}$ J)

   $\phi_0 = 4.2$ ev $= 6.72 \times 10^{-19}$ J)

6. $\lambda = 0.135$ nm $(\therefore \lambda = \frac{h}{p} = \frac{h}{m\,v})$

7. $\lambda = 1.64\ A^0$ $(\therefore \lambda = \frac{12.27}{\sqrt{V}}\ A^0)$

8. $\lambda = 1.13\ A^0$ $(\therefore \lambda = \frac{h}{m\,v})$

9. Momentum of electron (or) photon :

   $P = \frac{h}{\lambda} = 6.63 \times 10^{-25}$ m

10. No of photons per second per m^2 = N = 3. 84 x 10^2 (photons / m^2 s)

    $(\therefore N = \frac{P}{E} = \frac{P\,\lambda}{h\,c})$

IV. MULTIPLE CHOICE QUESTIONS – HINTS

1. (c) --Cathode rays (electrons) are fundamental, universal constituents of matter. So e/m of electron is constant.
2. (D) --cathode rays are deflected by electric and magnetic field shows particle nature of electrons.
3. (B) ---Specific charge = $\frac{q}{m} = \frac{charge}{mass}$ $(\frac{e}{m})$ of α particle = $\frac{2\,c}{4\,mp} = \frac{e}{2\,mp}$

   $(\frac{e}{m})$ of positron = $\frac{e}{mp}$ $(\frac{e}{m})$ of neutron = $\frac{0}{4\,mn} = 0$

   $(m_e < m_p < m_n)$(mass of neutron slightly greater than mass of proton)

4. (C) ----$m = \frac{mo}{\sqrt{1-\frac{V^2}{C^2}}} = \frac{mo}{\sqrt{1-\frac{c^2}{C^2}}} = \frac{mo}{\sqrt{1-1}} = \frac{mo}{0} = \infty$

   $\lambda = \frac{h}{p} = \frac{h}{m\,v} = \frac{h}{\infty} = 0$

5. (C) ----$\lambda = \frac{h}{\sqrt{2\,M\,E}}$

   If λ = constant, $E \alpha \frac{1}{m}$

   So $m_e < m_p < m_\alpha$, then

   $E_e > E_p > E_\alpha$ then $\therefore E_1 > E_3 > E_2$

6. (D) -----$\lambda = \frac{h}{\sqrt{2\,M\,E}}$

   $\lambda_1 = \frac{h}{\sqrt{2\,M\,E1}} = \frac{h}{\sqrt{2\,M\,2\,E}} = \frac{\lambda}{\sqrt{2}}$

7. (B) -----$\mu_x = \mu \sin\theta$

$$\lambda = \frac{h}{m\,v} = \frac{h}{m\,\mu\,x} = \frac{h}{m\,\mu \sin\theta}$$

8. (D)---- $V = \sqrt{2\,g\,H}$; $\lambda = \frac{h}{m\,v} = \frac{h}{m\,\sqrt{2\,g\,H}} = \left(\frac{h}{m\sqrt{2g}}\right)\frac{1}{\sqrt{M}}$

$\lambda \propto H^{-1/2}$

9. (A) ----- $\lambda = \frac{1.227}{\sqrt{V}}$ nm $= \frac{1.227}{\sqrt{100}} = 0.123$ nm

10. (B) ---- $\lambda = \frac{h}{\sqrt{2\,M\,E}}$ K. E = E = constant

$\lambda \alpha \frac{1}{\sqrt{m}}$ $m_\alpha > m_p > n_e$

11. (D) ----- $K_{max} = \frac{h\,c}{\lambda} - \phi_0$

The radiation which has wave length greater than visible light, no photo electric effect occurs. Here only λ of U. V. rays < λ of visible light

12. (D) ------- $K_{max} = \frac{1}{2}\, m\, v_1^2 = h\,v_1 - \phi_0 = 2 - 1 = 1$

$K_{max} = \frac{1}{2}\, m\, v_2^2 = h\,v_1 - \phi_0 = 5 - 1 = 4$

$$\frac{V_1}{V_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

13. (C) ------ $\frac{1}{2}\, m\, v_1^2 = h\,f_1 - \phi_0$

$\frac{1}{2}\, m\, v_2^2 = h\,f_2 - \phi_0$

→ $\frac{1}{2}\, m\,(v_1^2 - v_2^2) = h\,(f_1 - f_2)$

→ $v_1^2 - v_2^2 = \frac{2\,h}{m}\,(f_1 - f_2)$

14. (D)------ $\frac{P_e}{P_\alpha} = \frac{\lambda_\alpha}{\lambda_e}$ $\lambda_e = \frac{h}{\sqrt{2 m_e e\, V}}$

$$\lambda_{\alpha} = \frac{h}{\sqrt{2m_{\alpha}(2e)\,V}}$$

15.(B) ---- E = h v = $\frac{h\,c}{\lambda}$

16. (C)

17. (A) ------N = $\frac{P}{E}$ = $\frac{2\,x\,10^{-3}}{6.63\,x\,10^{-34}\,x\,6\,x\,10^{14}}$ (∴ E = hv)

18. (C) ----- $\lambda = \frac{h\,c}{\emptyset_0}$ ($\phi_0 = h\,v_0 = \frac{h\,c}{\lambda_0}$)

19. (B) ------ K max = e V_0 = 4 e V

Stopping potential V_0 = 4 V

20.(D) ----- $\lambda_1 = \frac{h}{\sqrt{2\,M\,E}}$, $\lambda_2 = \frac{h}{\sqrt{2\,M\,(\,4E)}}$ = $\frac{\lambda_1}{2}$

$\frac{\lambda_2 - \lambda_1}{\lambda_1}$ x 100 = - 50%

21.(A) Δ P = P $\lambda = \frac{h}{p}$

Δ λ = 1 % ƛ = $\frac{\lambda}{100}$ $\frac{\Delta\,P}{P_i} = \frac{\Delta\,\lambda}{\lambda}$

$\frac{P}{P_i} = (\frac{\lambda}{100})\ x\ \frac{1}{\lambda}$

22. (C)
23. (D)
24. (A)
25. (A)

IX . PROBLEMS (LEVEL- II)

1. Number of emitted photo electrons per second = 10''

   Maximum energy = 5 e V
2. Work function of metal = ϕ_0 = 3.7 eV

3. Maximum number of photo electrons (v) = 1.04 x 10 ^{7}
4. Work function of metal = ϕ_0 = 1.1 e V
5. De- Broglie wave length of final particle is

$$\frac{1}{\lambda} = \sqrt{\frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}} \quad \text{(or)} \quad \lambda = \lambda_1^2 + \lambda_2^2$$

6. $\frac{\lambda_A}{\lambda_B}$ = 2 $\sqrt{50}$ = 14.14
7. Speed of electron = 1.45 x 10 ^{6} m/s
8. Value P = 2
9. $\frac{\lambda_1}{\lambda_2}$ = $\sqrt{2}$

WORKBOOK : II YEAR

SUBJECT : PHYSICS

TOPIC : ATOMS

CONTENT :

Name of the Lecturer : R. V. V. Surya Kumari

J. L. in Physics

GJC, Pusapati Rega,

Vizianagaram District

9490971989

ATOM

1) Atom as a whole is electrically neutral, it contains equal amount of positive and negative charges.

2) According to Thomson model, the entire mass and + ve charge of the atom are uniformly distributed. 3)According to Rutherford's model, most of the mass of the atom and all its +ve charge are concentrated in a tiny nucleus, and the electrons revolve round it.

4) Rutherford nuclear model has two main difficulties in explaining the structure of atom.

a)It predicts that atoms are unstable, because the unaccelerated electrons revolving around the nucleus must spiral into the nucleus. This contradicts the stability of atom.

b) It cannot explain the characteristic line spectra of atoms of different elements .

5) To explain the stability of atoms, as well as the line spectra emitted by atoms. Niel's Bohr proposed a model for hydrogenic atoms.

He introduced three postulates and laid the foundations of quantum mechanics.

a) In a hydrogen atom, an electron revolves in certain stable orbits, (stationary orbits) without the emission of radiant energy.

b) The stationary orbits are those for which the angular momentum is some integral multiple of $\frac{h}{2\pi}$; L = $\frac{n\,h}{2\pi}$ n is an integer called a quantum number.

c) Electrons make a transition from one stationary orbit to other. If electron jumps from an orbit of higher energy E_2 to an orbit of lower Energy E_1, E_2-E_1 = hv

6) DC Broglie's hypothesis that electrons have a wave length. Gave an explanation for Bohr's quantized orbits by bringing in the wave particle duality.

7) Bohr's model is applicable only to hydrogenic atoms. It cannot be extended to even two electrons atoms such as helium. This model is also unable to explain for the relative intensities of the frequencies emitted even by hydrogen atoms.

8) **Formulas :**

- The impact parameter related to angle of scattering is b = $\frac{P}{2\tan\frac{\theta}{2}}$;

b = impact parameter ; d = distance of closet approach

- The relation between B & scattering angle is tan $\frac{\theta}{2} = \frac{d}{2b}$, d= $\frac{Z\,e^2}{\pi\varepsilon_0 m v^2}$
- KE of the hydrogen atom KE = $\frac{e^2}{8\,\pi\varepsilon_0 r}$; PE = $\frac{-\,e^2}{4\,\pi\varepsilon_0 r}$; TE = $\frac{-e^2}{8\,\pi\varepsilon_0 r}$
- The relation between the orbit radius & electron velocity is hydrogen atom is

  r = $\frac{e^2}{4\,\pi\varepsilon_0 (mv)^2}$
- Excitation potential E_n = $\frac{-13.6}{n^2}$ ev
- For a line spectrum of H atom $\frac{1}{\lambda}$ = R ($\frac{1}{n^2} - \frac{1}{m^2}$) m > n

For Lyman series n = 1 with m > 1

For Balmer series n = 2 with m > 2

Pascken series n = 3 with m > 3

R = 1.097 x 10^{7} /m

h = 6.63 x 10^{-34} J

$\frac{1}{4\,\pi\,\epsilon_0}$ = 9 x 10^9 n M^2 /C^2

m = 9.1 x 10^{-31} g

$\frac{me^2}{8n^2\varepsilon 0^2}$ = - 13.6 ev

e = 1.6 x 10^{-19} C

FILL UP THE BLANKS :

1) According of Bohr's quantum condition, an electron can revolve any in those orbits in which the angular momentum is an integral multiple of _______________

2) In the Bohr model of the hydrogen atom the ratio of kinetic energy to the total energy of the electron is a quantum state is ___________

3) The perpendicular distance of the initial vector of the alpha particles from the centre of the nucleus is called __________________

4) The excitation energy of the hydrogen atom in the ground state is _________________

5) The orbit of the electron around the nucleus can take only some special values of radius are called ___________

6) The ionization potential of the hydrogen a tom is _______________

7) The charge neutrality and the large empty space inside the atom is suggested by _____________

8) The Equation $E_2 - E_1 = \frac{h\,c}{\lambda}$ is called as ____________

9) When electron revolves around the nucleus the centripetal force is given by ______________

10) Hydrogen atom, singly ionized Helium, doubly ionized Lithium these are the examples of ___________

II. STATEMENTS WITH TRUE OR FALSE AND OTHERS :

1) The Rutherford scattering of a particles by atoms show that

a) The atom as a whole is positively charged

b) The atom has a very small positively charged core at the centre

c) There is no charged particle inside the atom

d) the atom consists of uniformly distributed positive and negative charged particles.

2) The electron is a hydrogen atom makes a transition from an excited state to the ground state, which of the following statements is true.

a) Its kinetic energy increases and its potential energy and total energy decreases.

b) Its kinetic energy decreases and potential energy increases its total energy remains the same.

c) its kinetic and total energies decrease and its potential energy increases

d) its kinetic, potential and total energies decrease.

3) Which of the following statement is not true.

a) For hydrogen like atom its electron energy only depends on n.

b) The various lines in the atomic spectra are produced when electrons jumps from higher energy state to lower of photons are emitted.

c) Bohr model unable to explain the relative intensities of the frequencies in the spectrum.

d) Bohr model is applicable to two electron atom.

4) Consider the spectral line resulting from the transition n ⇒ 2 ⇒= n=1 in the atoms and ions given below, the shortest wave length is produced by

a) Hydrogen atom

b) Deuterium atom

c) Singly ionized helium

d) doubly ionized Lithium.

5) Check the correctness of the following statements about Bohr model of hydrogen atom.

i) The acceleration of the electron in n = 2 orbit is more than in n = 1 orbit

ii) the angular momentum of the electron in n =2 orbit is more than n = 1 orbit

iii) the KE of the electron is n = 2 orbit is less than n = 1 orbit

a) all the statements are correct b) only (i) & (ii) are correct

c) only (ii) & (iii) are correct d) only (iii) & (i) are correct

6) According to Bohr's theory of hydrogen atom, the angular momentum of an electron in any orbit of hydrogen atom is

a) directly proportional to the radius of the orbit

b) inversely proportional to the radius of the orbit

c) directly proportional to the radius of the orbit

d) directly proportional to the square root of the radius of the orbit.

7) Which of the following statement is false.

a) The electron is a hydrogen at room temperature spends least time in ground state.

b) the energy needed to release an electron from its ground state is called ionization energy

c) To ionize a hydrogen atom an electron from the ground stat 13.6 ev of energy must be supplied.

8) Which of the following statement is not true.

a) According to the classical electromagnetic theory the frequency of the Em waves emitted by the revolving electrons is equal to the frequency of the revolution around the nucleus.

b) The energies of the excited states come closer and closer together as quantum number n decreases.

c) The various lines in the atomic spectra are produced when electrons jump from higher energy state to a lower energy state and protons are emitted.

d) De Broglie hypothesis provide an explanation for Bohr's second postulate for the quantisation of angular momentum of the orbiting electron.

III. Match the following :

1.	**LIST – I**	**LIST – II**
	a) Plank's constant	a) 1.09×10^7/m
	b)Energy of hydrogen atom in ground state	b) 10^{-15} m
	c) Rydberg's constant	c) 6.63×10^{-34} JS
	d)1 fermi	d) – 13.6 ev

a)a → b , b →c, c →d, d→ a   b)a→c , b →d, c→ a, d→ b

c)a →c, b →d, c→ b , d→ a   d) a→ d, b →c, c ≥a, d→b

2) LIST – I **LIST –II**

a) Lyman series a)Line emission spectrum
b) Balmer series b) infra red region
c) Pachen series c) visible region
d) light emitted by sodium lamp d) ultraviolet region

a) a → d , b → c, c→ b , d → a
b) a → c, b → d, c → a, d → b
b) a→ a, b→ c, c→ d, d→ b
d) a→ b , b→ c, c→ a, d→ b

3) LIST – I **LIST –II**

a) radius of the hydrogen atom rn a) $\frac{-13.6}{n^2}$ ev
b) total energy of the hydrogen electron b) $n^2 h^2$ / $4 \pi^2$ m K. e^2
c) Rutherford scattering formula c) Z Ω / 2 ϵ_0 n h
d) speed of the hydrogen electron d) N Ø = $\frac{Z^2}{sin^4 \frac{Ø}{2}}$

a) a → c, b→ a , c →d, d →b
b) a→d, b→ c, c →a, d→ b
c) a→ b , b →a , c→ d, d→ c
d) a→ a, b→ c, c→ d, d→ b

4) LIST – I **LIST –II**

a) charge of the electron a) 3 x 10^{8} m/sec
b) mass of the electron b) 5.29 x 10^{-11} m
c) velocity of light c) 9.1 x 10^{-31} kg
d) Bohr radius a_0 d) 1.6 x 10^{-19} J

a) a →b , b →c, c→ d, d→ a
b) a→ d, b →a, c→b , d→ b
c) a→ c , b →d, c→ a, a→b
d) a→ d , b →c, c→ a, d→ b

5) LIST – I **LIST –II**

a) Lyman series a) $\frac{1}{\lambda}$ = R ($\frac{1}{4} - \frac{1}{n^2}$)
b) Balmer series b) $\frac{1}{\lambda}$ = R ($1 - \frac{1}{n^2}$)
c) Paschen series c) $\frac{1}{\lambda}$ = R ($\frac{1}{16} - \frac{1}{n^2}$)
d) Bracket series d) $\frac{1}{\lambda}$ = R ($\frac{1}{9} - \frac{1}{n^2}$)

a) a →a, b → c, c→ d, b→ a b) a →b , b→ a, c →d, d→c
c) a→ d, b → c, c →d, d →a d) a→ b, b→ d, c →a, d →c

Multiple Choice – Level – I

1) The radius of the first electron orbit of a Hydrogen atom is 5.3×10^{-11} m. What is the radius of the second orbit ?

a) 2×10^{-10} m b) 2.12×10^{-10} m c) 2.12×10^{-10} m d) 2.3×10^{-10} m

2) The total energy of an electron in the first excited state of hydrogen atom is -3.4 ev . What is the kinetic energy of electron in this state ?

a) 3.4ev b) -3.4 ev c) 2.4 ev d) -2.4 ev

3) α particles are projected towards nuclei of the following metals with the same KE, towards which metal the distance of closest approach is minimum

a) Cu (Z = 29) b) Ag (Z = 47) c) AU (Z = 79) d) Pd (Z =46)

4) If the hydrogen atom makes transition from n = ∞ to the state n = 1 the wave length emitted is given by

a)9.12×10^{-9}m b) 91.2×10^{-9}m c) $.912 \times 10^{-9}$m d)$.0912 \times 10^{-9}$

5) If the binding energy of electron in a hydrogen atom is 13.6 ev, the energy required to remove the electron from the first excited state of Li^{++} is

a) 13.6 ev b) -13.6ev c) 30.6ev d) -30.6ev

6)How many different wave lengths may be observed in the spectrum from a hydrogen sample of the atoms are excited to third excited state.

a) 2 b) 4 c) 6 d) 8

7) The angular momentum of the electron in third orbit of hydrogen atom, if the angular momentum in the second orbit of hydrogen atom is L, is

a) L b) $\frac{3}{2}$ L c) 3 L d) $\frac{2}{3}$ L

8) The distance of closest approach of an α particle fired towards a nucleus with momentum P is r. What will the distance of closest approach when the momentum of particle 2P is

a) $\frac{r}{4}$ b) 2r c) $\frac{r}{2}$ d) r

9) Find the wave length of the emitted radiations, if the electron in hydrogen atom jumps from the third orbit to second orbit is

a) $\frac{36}{TR}$ b) $\frac{-36}{7R}$ c) $\frac{5}{3R}$ d) $\frac{36}{5R}$

10)Calculate the ratio of the frequencies of the long wave length limits of the Balmer and Lyman series of hydrogen is

a) $\frac{23}{5}$ b) $\frac{13}{16}$ c) $\frac{5}{27}$ d) $\frac{27}{5}$

LEVEL – II

1) The wave length of first member of Balmer series is 6563 A^0 . Calculate the wave length of second member of Lyman series.

a) 1023 A^0 b) 1022 A^0 c) 1025 A^0 d) 1030 A^0

2) What is the wave length of the radiation emitted when the electron in a hydrogen atom jumps from n = α to n = 2

a) 365 nm b) 362 nm c) 360 nm d) 355nm

3) The excitation energy of a hydrogen like ion in its first excited state is 40.8ev . Find the energy needed to remove electron from the ion.

a) 54 ev b) – 40.8ev c) 54.4 ev d) -54.4 ev

4) An alpha particle of energy 5 MEV is scattered through 188 by a fixed uranium nucleus. The distance of closest approach is of the order of

a) 5.299 x 10^{-9} cm b) 5.299 x 10^{-12} cm c) 5.2 x 10^{-8} cm d)5.4 x 10^{-8} cm

5) Find the wave length in a hydrogen spectrum between the range 500 mm to 700 mm is

a) 634nm b) 654 nm c) 632 nm d) 650nm

6) If $\left(\frac{.51\ x\ 10^{-10}}{4}\right)$ m is the radius of smallest electron orbit in hydrogen like atom, then this atom is

a) Be^{3+} b) He^{2+} c) Li^{3+} d) H

7) The energy needed to detach the electron of a hydrogen like ion in the ground state is 4 rydberg. What is the wave length of the radiation emitted when the electron jumps from the first excited state to the ground state.

a) 28.4nm b) 30.4nm c) 28.6nm d) 30.2nm

8) A hydrogen sample is prepared in a particular excited state. A photons of energy 2.55 ev get absorbed into the sample to take some of the electrons to a further excited state B. Find the quantum numbers of the states A & B.

a) 1, 4 b) 4, 1 c) 4, 2 d) 2, 4

9) It is found experimentally that 13.6 ev energy is required to separate a hydrogen atom into a proton and an electron. Compute the orbital radius of the velocity of the electron in a hydrogen atom.

a) 5.3×10^{-11} m, 2.2×10^{6} m/sec

b) 5.3×10^{-9} m , 2×10^{6} m/sec

c) 4.3×10^{-11} m, 2×10^{6} m /sec

d) 4×10^{-11}m, 2×10^{6} m/sec

10)According to the classical electromagnetic theory calculate the initial frequency of the light emitted by the electron revolving around a proton in hydrogen atom.

a) 6.6×10^{12} HZ b) 6.6×10^{15} HZ

c)4.6×10^{12} HZ d) 4.6×10^{15} HZ

EXERCISE PROBLEMS FOR PRACTICE :

1. Prove that the ionisation energy of hydrogen atom is 13.6 ev
2. Calculate the ionization energy for a lithium atom.
3. The wave length of the first member of Lyman series is 1216 A. Calculate the wave length of second member of Balmer series.
   A) 4864 A^0
4. The total energy of an electron in the first excited state of the hydrogen atom is -3.4 ev . What is the potential energy of the electron in this state
   A) – 6.8ev
5. Using the Rydberg formula, calculate the wave length of the firs four spectral lines in the Balmer series of the hydrogen spectrum.
   A) λ_{32} = 6575A ; λ_{42} = 4870 A ; λ_{52}= 4348A; λ_{62}= 4109 A
6. The ground state energy of hydrogen atom is -13.6 ev . What are the kinetic and potential energies of the electron in this state ?

KEY

I. FILL UP THE BLANKS :

1. $\frac{h}{2\pi}$
2. -1
3. Impact parameter
4. 10.2 ev
5. Stationary orbits
6. 13.6 ev
7. Rutherford
8. Einstein's Plank's equation
9. $\frac{mv^2}{x}$
10. Hydrogenic atoms

II. Statements with true or false and others

1.B 2. A 3. D 4. D 5. C 6.D 7. A 8. B

III. Matchings :

1. B 2. A 3. C 4. D 5. B

IV. Multiple Choice : Level 1

1. $r \; \alpha \; n^2$ $\frac{r_2}{r_1} = \frac{2^2}{1^2} = 4$

   $r_2 = 4\, r_1 = 2.12 \times 10^{-10}$ m

   Answer : B

2. KE = - (TOTAL E)

   KE = - 3.4

   Total E = - (-3.4) = 3.4 ev

   Answer : A

3. $(K.E)_\alpha$ = PE at distance of closest approach

   KE = $\frac{1}{4\pi\epsilon_0}$, r α q_2

   It is minimum for small q_2 i. e. Cu = (Z = 29)

   Answer : A

4. $\frac{1}{\lambda}$ = R (1- 0) = R

   R = 1.0973 X 10^{7} /M

   $\lambda = \frac{1}{R}$ - 9. 12 X 10^{-9} M

   Answer : B

5. $E_n = -\frac{13.6}{n^2} Z^2$ ev

   Z = 3 for Li, n = 2

   $E_1 = -\frac{13.6}{n^2} \times 3^2 = -30.6$ ev

   Answer : D

6. $N = \frac{n\,(n-1)}{2}$, for third excited state n = 4

   $N = \frac{4\,(4-1)}{2} = \frac{4 \times 3}{2} = 6$

   Answer : C

7. Angular momentum = $\frac{n\,h}{2\pi}$

$n=2$, L = $\frac{2\ x\ h}{2\pi}$ = $\frac{h}{\pi}$

n = 3, L' = $\frac{3\,h}{2\pi}$, = $\frac{3\,L}{2}$

Answer : B

8. KE = PE $\frac{P^2}{2\,m}$ = $\frac{1}{4\pi\epsilon_0}$. $\frac{Q_1\,Q_2}{R}$

r α $\frac{1}{P^2}$ momentum of a particle will be the closest approach of $\frac{r}{4}$

Answer : A

9. $\frac{1}{\lambda}$ = R ($\frac{1}{4}$ - $\frac{1}{9}$) , λ = $\frac{36}{5R}$

Answer : D

10. λ_B = $\frac{36}{5R}$

λ_L = $\frac{4}{3R}$

$\frac{\lambda B}{\lambda L}$ = $\frac{27}{5}$

Answer : D

V. Multiple Choice : Level 2

1. $\frac{1}{\lambda}$ = R ($\frac{1}{n_1^2}$ - $\frac{1}{n_2^2}$) = First order

$\frac{1}{6563}$ = R ($\frac{1}{2^2}$ - $\frac{1}{3^2}$) = $\frac{5\,R}{36}$ ……………(1)

$\frac{1}{\lambda}$ = R ($\frac{1}{1^2}$ - $\frac{1}{3^2}$) = $\frac{8\,R}{9}$ ………..(2) second order

$\frac{(1)}{(2)}$ $\frac{\lambda^1}{6563}$ = $\frac{5R\ X\ 9}{36\ X\ 8\ R}$, λ' = 1025 A^0

Answer : C

2. E_2 = $\frac{-13.6}{4}$ ev = - 3.4 ev

The energy of n = α state is zero.

λ = $\frac{h\ c}{\Delta c}$ = $\frac{1242\ ev}{3.4\ ev}$ nm = 365 nm

Answer : A

3. $E = +13.6\ Z^2 \left(\frac{1}{1^2} - \frac{1}{2^2} \right)$

   $= 13.6\ Z^2 \times \frac{3}{4}$; Z = 2 E = 40.8 EV

   $E = \frac{R\,h\,c\,Z^2}{12}$ = - 4 X 13.6 = - 54.4 EV

   Answer : D

4. $q_1 = q_2\ e$, $q_2 = +2e$

   Loss in KE = gain in PE

   $\frac{1}{2}\ mv^2 = \frac{K\ 2\ q_1 q_2}{r^2}$

   $R = \frac{2\ K q_1 q_2}{m\ v^2} = \frac{2\ x\ 9\ x\ 10^9\ x\ (\ 1.6\ x\ 10^{-19})^2\ x\ 92}{5\ x\ 1.6\ x\ 10^{-13}}$

   = 529.92 x 10^{-16} m or 5.299 x 10^{-12} cm

   Answer : B

5. $\frac{h\ c}{\lambda} = \frac{1242\ ev}{500\ nm}$ nm = 2.44 ev For 500 nm

   $\frac{1242\ ev}{700\ nm}$ nm = 1.77 ev For 700 nm

   The energy of the photon emitted in the transistor n = 3 to n = 2 is

   Δ E = (34 – 1.5) q = 1.9 ev

   $\lambda = \frac{h\ c}{\Delta\ E} = \frac{1242\ ev}{1.9\ ev}$ nm = 654 nm

   Answer : B

6. radius of hydrogen like atom

   $r_n = \frac{n^2}{Z}\ r_0$

   r_0 = .51 x 10 -10 m

   $r_n = \frac{.51\ X\ 10^{-10}}{4}$ at ground state n = 1

   Hence it is Berilium Be^{3+}

   Z = 4

   Answer : A

7. 1 rydberg = 13.6 ev E_1 = -4 x 13.6 ev

For n = 2 $E_2 = \frac{E_1}{4}$ = -13.6 ev

$E_2 - E_1$ = 3 x 13.6 ev = 40.8 ev

The wave length of the radiation emitted is

$\lambda = \frac{h\,c}{\Delta\,E} = \frac{1242\;e\,v}{40.8\;ev}$ nm = 30.4 m

Answer : B

8) E_1 = -13.6 ev ; E_2 = -3.4 ev ; E_3 = -1.5 ev

E_4 = -18.5 ev, E_5 = -.54 ev

The difference of 2.55 ev can only be observed in transition from n = 2 to n = 4

So, A has quantum no 2 & B has 4.

Answer : D

9) TE - 13.6 ev = -13.6 x 1.6 x 10^{-19} J = - 22 x 10^{-18} J

$\frac{-e^2}{8\pi\varepsilon_0}$ = - 2. 2 x 10^{-18} J

$r = \frac{-e^2}{8\pi\varepsilon_{0\,E}} = \frac{9\,x\,10^9\,x\,(1.6\,x\,10^{-19})^2}{2\,(-2.2)\,x\;10^{-18}}$ = 5. 3 x 10^{-11} m

$v = \frac{e}{\sqrt{4\,\pi\,\epsilon_0\,m\,r}}$ = 2. 2 x 10^{6} m/ sec

Answer : A

10) The radius of the hydrogen atom is = 5.3 x 10^{-11} m

The velocity of electron of hydrogen atom is = 2. 2 x 10^{-6} m /sec

$M = \frac{V}{2\,\pi\,r} = \frac{2.2\,x\,10^{-6}\,m/sec}{2\pi\,x\,5.3\;x\,10^{-11}m}$ = 6. 6 x 10^{15}

Answer : B

14. NUCLEI

❖ Synopsis

- The Nucleus of an atom is at centre and was discovered by Rutherford from α-ray scattering. Most of the atom is empty and its mass is concentrated at the centre, the entire positive charge of an atom lies in the nucleus with spherical shape, contains neutrons and protons called nucleons. The radius of an nucleus is 10^4 times smaller than the atom.
- The nuclei represent in the notation as $_ZX^A$, in which Z denotes atomic number, A denotes mass number. The number of neutrons is N = A-Z.
- Mass of the nucleus is equal to sum of masses of protons and neutrons that are present in the nucleus. Its radius is estimated around 10^{-15}m called Fermi.
- Scattering of α-particle, protons and neutrons show that the volume of the nucleus is directly proportional to its mass number.

  V a A

  R a $A^{1/3}$

  R= $R_0 A^{1/3}$, where R_0 is around 1.2 Fermi.
- The density (mass to volume ratio) of nucleus is 2.3×10^{17} kg/m^3 and is independent of atomic mass number, the density is maximum at the centre and gradually falls to zero to the edge. The effective value of radius of the nuclei is the distance between the centre to the point where density becomes half.
- The masses of small particle like proton, neutron and electron was measured with amu and is equal to (1/12)th of the mass of C-12 atom.

  1 atomic mass unit (amu) = 1.66×10^{-27} kg = 931.5 MeV
- James Chadwick discovered neutron, when beryllium nuclei were bombarded with α-particles.

  $_4Be^9 + {_2He^4} \rightarrow {_6C^{12}} + {_0n^1}$

  Neutron is electrically neutral and just larger than proton and is unstable outside the nucleus, it decays into proton. Inside the nucleus it behaves like as stable particle.

  $_0n^1 \rightarrow {_1H^1} + {_{-1}e^0}$ + anti neutrino
- Mass of proton is 1.0073 amu and neutron is 1.0087 amu. The mass of electron is 1837 times smaller than the proton.
- **Isotope:** Atomic nuclei having same atomic number but different mass numbers. They occupy same position in the p[periodic table and possess identical chemical properties as they have same electronic configuration.

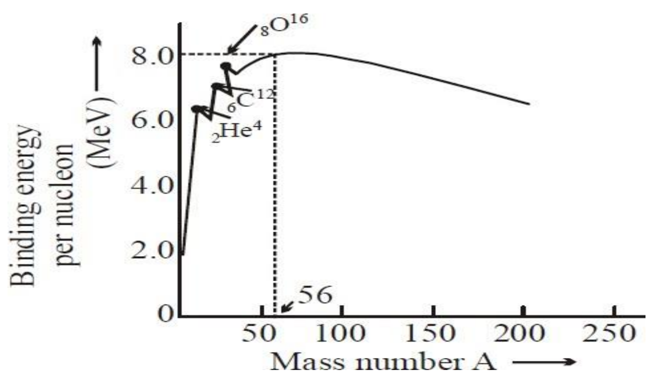
  Ex: (a) $_3Li^6$, $_3Li^7$ (b) $_1H^1$, $_1H^2$, $_1H^3$
- **Isotones:** Atomic nuclei having same number of neutrons.

  Ex: (a) $_{17}Cl^{37}$, $_{19}K^{39}$ (b) $_7N^{14}$, $_8O^{15}$, $_9F^{19}$
- **Isobars:** Nuclei having same mass number but different atomic numbers. It has same number of nucleons.

  Ex: (a) $_{18}Ar^{40}$, $_{20}Ca^{40}$ (b) $_7N^{14}$, $_6C^{14}$
- **Isomers:** Nuclei having same mass number and atomic number but have different radioactive properties. They can be distinguished by their different life times and different magnetic moments.

  Ex: $_{35}Br^{80}$, $_{35}Br^{*80}$ are two isomers with different life times.

- **Isodiapheres:** Nuclei having different atomic number and mass number, but having same excess number of neutrons over protons (A-2Z).
  Ex: $_{11}Na^{23}$, $_{13}Al^{27}$
- **Nuclear forces**: These are the strongest forces in nature existing between nucleons arising due to exchange of π-mesons.
  Nuclear forces are spin dependent, charge independent, attractive and non-central short range forces. $F_{pp} = F_{pn} = F_{nn}$ is due to charge independent
  The force is maximum when spins aligned in parallel and minimum when aligned anti-parallel due to spin dependent.
  The ratio of gravitational, electrostatic and nuclear forces is $F_g: F_e: F_n = 1: 10^{36}: 10^{38}$
- Einstein mass energy equivalence relation $E= mc^2$
  Amount of energy released for the annihilation of an electron is 0.51 MeV.
  The energy released to 1 amu is around 931.5 MeV = 1.495×10^{-10}J
- **Mass defect:** Atomic mass is always less than the sum of the masses of constituents. The difference between total mass of the nucleons to the mass of the nucleus is called mass defect.
  Δm= [Zm_p + (A-Z) m_n-M] amu, where Z,A denote protons and mass number, m_p and m_n represents mass of proton and neutron, M represent mass of the nucleus.
- **Binding energy:** The energy required to bring the nucleons to form the nucleus is called binding energy. (Or) It is the energy required to separate the nucleons from nucleus.
  BE= Δm C^2 joule
  BE= [Zm_p + (A-Z) m_n-M] C^2 MeV.
  Binding energy per nucleon is called average binding energy (BE/A).
  Average Mass defect per nucleon is called packing fraction. (PF= Δm/A)
  If packing fraction is negative then the nucleus is more stable. If positive then the nucleus is unstable. Binding energy is not a measure of stability of a nucleus. However packing fraction measures the stability of a nucleus. Smaller the value of packing fraction, large is the stability.
  Packing fraction of $_6C^{12}$ is zero.
  The graph of binding energy per nucleon with mass number A is as shown below.



- **Observations from graph:**
  Binding energy per nucleon increases and then decreases slowly as mass number increases.
- Binding energy per nucleon gives a measure of stability of nucleus. More is binding energy per nucleon more is the stability of nucleus. Binding energy per nucleon is small for lighter nuclei and minimum for $_1H^2$ as 1.1 MeV.

- For A < 28 at A = 4n the curve shows some peaks at ${}_2He^4$, ${}_4Be^8$, ${}_6C^{12}$, ${}_8O^{16}$, ${}_{10}Ne^{20}$, ${}_{12}Mg^{24}$.
  This represents extra stability (even number of protons and neutrons) of these elements with respect to their neighbours.
- The odd-odd combination of stable nuclei is found only in the light elements (${}_3Li^6$, ${}_5B^{10}$), these are less stable than the above.
- The maximum value of binding energy is for Fe^{56}(8.8 MeV) and minimum for ${}_{92}U^{238}$ as 7.6 MeV at higher A value.
- For most of the nuclei, it ranges from 7.5 MeV to 8.8 MeV.
- Over a wide range the average Binding energy per nucleon is nearly 8 MeV.
  In order to attain higher value of binding energy per nucleon, the lighter nuclei may combine to form heavier nuclei called fusion or breaking of heavier nuclei into lighter nuclei called fission.
  BE/A varies by less than 10% above A = 10 suggests that each nucleon interacts with its neighbouring nucleon only.
  For A > 56, BE/A decreases because of the destabilizing effect of long-range coulombic force.
- Energy is released in fission because average binding energy is greater for fission fragments than the initial heavy nucleus.
- Similarly In fusion also average binding energy of the heavy nucleus formed as result of fusion is greater than the lighter nuclei.
  The nuclei having the number of nucleons equal to any one of the following numbers 2,8,20,28,50,82,126 are stable, called magic numbers.
- **Radioactivity:** In periodic table all elements after Bismuth (Z=83) are radioactive. It is the process by which an unstable nucleus achieves stability.
- Natural radioactive elements are: ${}_{84}Po$, ${}_{85}At$, ${}_{86}Rn$, ${}_{87}Fr$, ${}_{88}Ra$, ${}_{89}Ac$, ${}_{90}Th$, ${}_{91}Pa$, ${}_{92}U$.

  It is the spontaneous disintegration of the heavy nucleus of an atom. It occurs without external provocation.
  There are three main types of radioactive radiations.
  α-rays (i.e., Helium nuclei or α – particles)

  β-rays (i.e., electron or positron or β – particles)

  γ-rays (photons or gamma radiations)
- This process is not affected by chemical combination and changing physical environment other than nuclear bombardment.
- When a nucleus undergoes alpha or beta decay, its atomic number and mass number changes (in β-decay only atomic number changes) & it transforms into a new element.

$$\mathbf{{}_ZX^A \rightarrow {}_{Z-2}Y^{A-4} + {}_2He^4}$$

- It means that when nuclei emit an alpha particle (α-particle), it loses 2 units of charge and 4 units of mass. Its position in periodic table decreased by 2 units. When nuclei emits an alpha particle, its isodiaphere is formed.

$$\mathbf{{}_ZX^A \rightarrow {}_{Z-1}Y^A + \beta^+}$$

  It means that by emission of beta particle (β^+-particle), nucleus loses one unit of charge. It is surprising to note that a nucleus does not contain β^+ then how is it emitted.

  Reason: During β^+ particle (i.e., positron) decay, a proton converts into a neutron.

$$\mathbf{p \rightarrow n + \beta^+ + \text{neutrino}}$$

- β^- Particle (i.e., electron) decays, when inside the nucleus a neutron converts into a proton.

$$\mathbf{n \rightarrow p + \beta^- + \text{anti neutrino}}$$

- Since β^-particle is an electron (or positron), so the loss of mass in this decay is negligible.

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$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + \beta^{-}$

In β^-decay the daughter element is one place forward in the periodic table, and its atomic number increased by one unit, without changing the mass number. When nuclei emits β particle, its isobar is formed.

- When a nucleus emits a gamma ray, neither the mass nor the charge of the nucleus changes.

$_{Z}X^{*A} \rightarrow {}_{Z}X^{A} + \Upsilon$

The gamma ray(γ-ray) is photon & it carries away some energy from the nucleus & nucleus returns from excited state(unstable state) to ground state (stable state)

- α and β-particles are not emitted simultaneously. ϒ rays are emitted after the emission of α and β-particle. Α, β and γ-rays are known as **Becquerel rays.**
- The energy spectrum in the case of β-particles is continuous but that of α and γ-rays is a line spectrum. This means that β particles are emitted with any amount of kinetic energy.
- **Properties α–Rays:**

It is a positively charged particle & contains a charge of 3.2×10^{-19} coulomb (exactly double the charge of electron). It is a combination of two protons and two neutrons, represented as $_{2}He^{4}$.
The mass of α-particles is 6.645×10^{-27}kg (It is equal to mass of a helium nucleus). Actually α-particle is nucleus of helium, hence it is called doubly ionized helium.
They (α-particles) get deflected in both electric & magnetic fields.
The velocity of α-particle is very less than the velocity of light i.e. $V_\alpha = C/10$, where C is velocity of light.
The range of α-particle in air depends on radioactive substance gas through which α particle is moving and pressure and temperature of the gas.
The ionization power of α-particle is higher than both β (100 times of β & 10,000 times of ϒ) and ϒ particle.
The penetrating power of α particle is lowest (in comparison to β & ϒ particles). It is 1/100 times of β-particles & 1/10,000 times of ϒ –rays.
The α-particles can produce fluorescence in barium platinocyanide and zinc sulphide.
They show little effect on photographic plate and heating effect on stopping.

- **Properties of β-Rays:**

The beta particles (i.e., β^- or β^+) may be positive & negative particle & contain 1.6×10^{-16} C of charge. Actually β^- is electron & β^+ is positron.
They get deflected in both electric & magnetic field.
The velocity of β-particle varies between 0.01C to .99C, where C is velocity of light. Soft β-rays have low velocity and hard one has higher velocity.
The mass of β particle is relativistic, because its velocity is comparable to velocity of light
They have both ionization & penetration power. Ionization power less than α-particle and penetration power more than α-particle.
They produce fluorescence on barium platinocyanide & zinc sulphide.

- **Properties of ϒ-rays:**

They are electromagnetic waves as x-rays and are not deflected in electric & magnetic field, it means that they are charge less.
The velocity of ϒ-particle is equal to velocity of light.
The ionization power of gamma rays is less than β & α rays (1:100:1000) but penetration power more than β and α-rays (10000:100:1).
The ϒ-particles are emitted from the nucleus, while X-rays are obtained, when electron goes from one state to another in an atom.

When γ-rays photon strikes nucleus in a substance, then it gives rise to a phenomenon of pair production.

ϒ → electron + positron

The minimum energy of ϒ-rays required for this phenomena is 1.02 MeV, because the rest mass energy of β- particle is 0.51 MeV.

The emission of alpha particles occurs in natural activity, but beta emission occurs both in natural and artificial activity.

In every nuclear reaction Charge, mass number, linear momentum and angular momentum conserved.

β-particle cannot exists in nucleus. It is created and ejected at once at the time of β-decay. β-particle cannot exist in the nucleus because its wavelength is greater than the size of nucleus.

- **Radioactive decay:**

It states that "at any time the rate at which particular decay occurs in a radioactive substance is proportional to number of radioactive nuclei present."

If N is the number of nuclei at any time t & at t + dt time, it decrease to N-dN then the rate of decay of these nuclei is $\frac{-dN}{dt}$ (negative sign comes because N decreases as t increases). So according to Rutherford & Sodi,

$\frac{-dN}{dt} \propto N$ or $\frac{dN}{dt} = \lambda N$

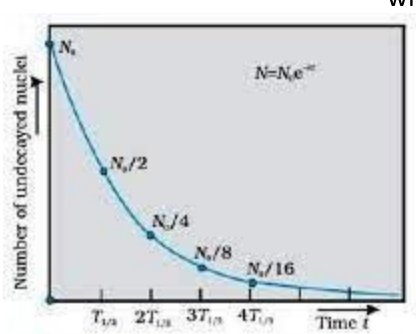
Where λ is decay constant (i.e., probability per unit time for a nucleus to decay) and it is constant for a particular nuclei, but different for different nuclei. By integration of above equation withrespect to time we get

$N = N_o e^{-\lambda t}$

where N_o is the number of nuclei at t = 0.

- **Activity:** The number of decays per unit time or decay rate is called activity(R).

$[R] = \left[\frac{dN}{dt}\right] = N_o \lambda e^{-\lambda t} = R_o e^{-\lambda t}$ where $R_0 = N_0 \lambda$



The S.I. unit of R is Becquerel,

1 Becquerel = 1 Bq = 1 decay/sec and 1 curie = 1 Ci = 3.7×10^{10} decay/sec

The other unit of radioactivity is rutherford.

1 rutherford = 10^6 decay/sec

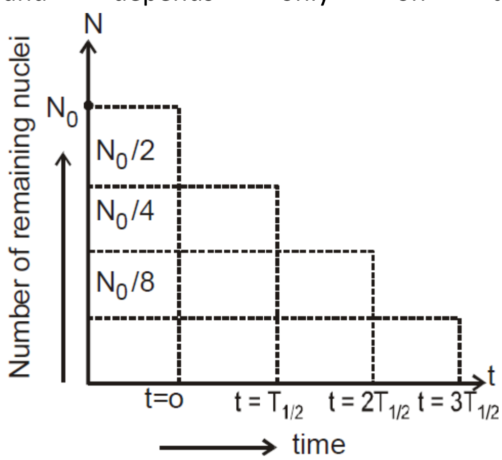
$\Rightarrow t = \frac{2.303}{\lambda} \log \frac{N_0}{N} \left[\text{and } \frac{N_0}{N} = \frac{m_0}{m}\right]$

m_0 = mass at t =0 and m = mass at t = t.

- **Half-life period:** It is the time interval during which the number of atoms reduces to half of the initial number of atoms in the sample. At $T = T_{1/2}$, N becomes N/2.

$$T_{1/2} = \frac{0.693}{\lambda} = \frac{\log_e 2}{\lambda}$$

- The half life period of radioactive substance is independent of initial quantity of the substance and depends only on the nature of radioactive substance.



- **Mean life time:** The ratio of the total life time of all the radioactive atoms to the total number of atoms present in the substance is called average life or mean life given by,

$$\tau = \frac{1}{\lambda} = \frac{T_{1/2}}{0.693}$$

- The equivalent λ and τ for two nuclei A and B,

$$\lambda = \lambda_A + \lambda_B \text{ and } \tau = \frac{\tau_A \tau_B}{\tau_A + \tau_B}$$

- The mean life = 1.44 ×half life.
  Half life = 0.693× mean life.
- The activity of a substance that remains after decay is $1/2^n$, where n is ratio between mean life to average life.
- The fraction of substance that undergoes decay is $(1-1/2^n)$.
- When the rate of formation of daughter nuclei becomes equal to rate of its decay then this is called as state of radioactive equilibrium
  $N_A \lambda_A = N_B \lambda_B$ or $N_A / T_A = N_B / T_B$
- **Radioactive series:(additional information)**
  The heavy nuclides change their mass number by α decay and atomic number by α and β decay. They can decay to stable end products by four paths. The four paths have mass numbers given as 4n, 4n + 1, 4n + 2, 4n + 3 where n is integer. Last element of series is stable and has a decay constant zero. There are **four radioactive series**
- **Uranium (4n+2)** ${}_{92}U^{238} \rightarrow {}_{82}Pb^{206}$ Half life-4.47×10^{9} years
- **Actinium (4n+3)** ${}_{92}U^{235} \rightarrow {}_{82}Pb^{207}$ Half life-7.04×10^{8} years
- **Thorium (4n)** ${}_{92}Th^{232} \rightarrow {}_{82}Pb^{208}$ Half life-1.41×10^{10} years
- **Neptunium (4n+1)** ${}_{93}Nb^{237} \rightarrow {}_{83}Bi^{209}$ Half life-2.14×10^{6} years
  Neptunium series is artificial and other remaining are all natural series.

- **Carbon dating:**
  Carbon dating is the process of determination of time interval which has passed by making use of radioactive decay of a sample containing radioactive substance ($_6C^{14}$). It helps in calculating age of geological specimens like rocks, biological specimens likes bones of animals or trunk of trees and age of earth. The isotope of carbon $_6C^{14}$ is radioactive. It is formed in atmosphere by bombardment of nitrogen atoms with cosmic rays
  $_7N^{14} + {_0n^1} \rightarrow {_6C^{14}} + {_1H^1}$
- The $_6C^{14}$ combines with oxygen to form carbon dioxide which is absorbed by plants so concentration of $_6C^{14}$ is constant with time. The living plants and animals have a fixed ratio of $_6C^{14}$ to ordinary carbon $_6C^{12}$. When a plant or animal dies the content of $_6C^{14}$ decreases while that of $_6C^{12}$ remains constant. The ratio of two indicates the time that has passed since death of plant or animal. The time interval is calculated from the laws of radioactive disintegration.

  $$t = \frac{1}{\lambda}\log_e \frac{N_0}{N} = \frac{2.303}{\lambda}\log_{10}\frac{N_0}{N}$$

  where N_o is number of $_6C^{14}$ nuclei at time of death, λ is decay constant of $_6C^{14}$ and N is number of $_6C^{14}$ nuclei currently present in sample.
- **Nuclear fission:** It is a nuclear reaction, in which heavy atomic nuclei splits into two approximately equal parts, emitting neutrons (around 2.5) and liberating large amount of energy(200 MeV). Bohr and wheeler proposed liquid drop model to explain this fission.

  $$^{235}_{92}\mathrm{U} + {^1_0 n} \rightarrow {^{141}_{53}\mathrm{Ba}} + {^{92}_{36}\mathrm{Kr}} + 3\left({^1_0 n}\right) + 200\ \mathrm{MeV}$$

  When fission occurs due to slow neutrons, 2.5 neutrons are liberated after the reaction. Fission with fast neutrons may also occur, but the probability is very low. Delayed neutrons play an important role in chain reaction. Neutrons released spontaneously with fission are called prompt neutrons (99.36%). The percentage of delayed neutrons is 0.64%.
  It may occur even at normal temperature and pressure, and the average energy released per nucleon is around 0.83 MeV. The 0.1% of mass is converted into energy in the fission.
  Easily fissionable material is $_{94}Pu^{239}$, which is artificially formed element used in NAGASAKI (Japan). According to liquid drop model the heavy nuclei takes place the shape of dumbbell before splitting.
  Chain Reaction: A fission reaction continues once started and left to itself is called chain reaction, and neutrons increased in geometric progression. The number of fission in this case goes on increasing at a tremendous rate leading to the creation of a huge amount of energy in a very small time. Atomic bomb works on this principle(uncontrolled chain reaction).
  State of chain reaction depends neutron reduction factor given by the ratio between rate of neutrons produced to the rate of neutrons lost.
  $K = \frac{Rate\ of\ neutrons\ produces}{Rate\ of\ neutrons\ lost}$
  If K=1, chain reaction is in equilibrium
  If K<1, chain reaction is in retardation
  If K>1, chain reaction is in acceleration
  If K=0, chain reaction is stopped.
  Certain amount of mass is required to continue the chain reaction is called critical mass. If it is smaller than critical mass, it may escape from nuclear reaction.
- **Nuclear reactor:** It is a device in which nuclear fission is produced by controlled chain reaction, and used for the production of nuclear energy. First nuclear reactor was constructed by Fermi.
  The essential parts of nuclear reactor are
  Nuclear fuel: U^{233}, U^{235}, Pu^{239} and Th^{232} are the common fuels used.

Moderator: Graphite, heavy water (D_2O), Graphite, Beryllium are used as moderators to slow down the neutrons (or slow down the nuclear reaction).Heavy water is the best moderator.

A good moderator should have low atomic mass, poor absorption of neutrons.

Control rods: Cadmium, boron and steel rods are used as controlled rods to absorb excess neutrons. It controls the chain reaction. Cadmium is the best one.

Coolant: Water is used as coolant to remove the intense heat produced in the core. The most used gaseous coolant is CO_2 in large power reactors. Liquid sodium is the best coolant.

Protective shield: During working of reactor high energy rays and radiations are produced, which are harmful. Hence reactor shielded with concrete wall and lined with metal like lead.

The output power of the reactor is P=nE, where n stands for number of fissions per second and E stands for energy release per fission.

- **Breeder reactor**: It converts U^{238} non-fissionable to a fissionable material Pu^{239} or U^{235} and also generates electric power. Simply it produces more fissile fuel than it consumes.
  Dhruva is the only breeder reactor operated in INDIA.
- **Nuclear fusion:** It is the fusion of two or more light nuclei to form a heavy nucleus with a release of huge amount of energy.
  For a nuclear fusion to take place, very high temperature is required to overcome the coulombic repulsive forces acting between the nuclei. It is the principle of hydrogen bomb.
  The nuclear fusion reaction, which is the source of the energy of sun/ star are proton-proton cycle.
- **Proton-proton cycle:**
  ${}_1H^1 + {}_1H^1 \rightarrow {}_1D^2 + {}_{+1}e^0$
  ${}_1D^2 + {}_1H^1 \rightarrow {}_2He^3$
  ${}_2He^3 + {}_1H^1 \rightarrow {}_2He^4 + {}_{+1}e^0$
  And the resulted as $4\ {}_1H^1 \rightarrow {}_2He^4 + 2\ {}_{+1}e^0 + 26.7$ MeV
  Four protons combine to form Helium nucleus emitting two positrons with energy of 26.7 MeV.
  The Stars with mass 0.4 to 2.5 solar mass produce energy by carbon-nitrogen cycle. Stars with lower mass and lower temperature produce energy by proton-proton cycle.
  Light nuclei combine at temperature 10^7K to give heavier nuclei. Hence Fusion reactions are called thermo nuclear reactions. In fusion 0.7% of mass is converted into energy, the energy released per nucleon is around 6MeV. Hydrogen bomb is a fission-fusion bomb.
- **Carbon-Nitrogen cycle:**
  ${}_6C^{12} + {}_1H^1 \rightarrow {}_7N^{13}$
  ${}_7N^{13} \rightarrow {}_6C^{13} + {}_{+1}e^0$
  ${}_6C^{13} + {}_1H^1 \rightarrow {}_7N^{14}$
  ${}_7N^{14} + {}_1H^1 \rightarrow {}_8O^{15}$
  ${}_8O^{15} \rightarrow {}_7N^{15} + {}_{+1}e^0$
  ${}_7N^{15} + {}_1H^1 \rightarrow {}_6C1^2 + {}_2He^4$
  And the resulted as $4\ {}_1H^1 \rightarrow {}_2He^4 + 2\ {}_{+1}e^0 + 26.7$ MeV
  This cycle is possible in stars bigger than the sun at temperatures about 20×10^8K.
  Carbon acts like a catalyst in these nuclear reactions.

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❖ One word answer Questions

1. Protons, neutrons and electrons are the constituents in atom. The mass of the proton in-terms of electron mass is…………………………………………………
2. The radius of two nuclei found to be 1:2, what is the ratio of the mass numbers of these nuclei……………………………………
3. ($_6C^{12}$, $_6C^{14}$) ($_7N^{15}$, $_8O^{15}$) ($_7N^{17}$, $_8O^{18}$) are described ....respectively.
4. Mass of the nucleus is measured in amu, and size of the nucleus is measured in units of……………
5. A, B, C nuclei have average binding energies of 8.75 MeV, 7.85 MeV and 6.89 MeV. The increasing order of stability of the nucleus is …………………………………………………………………
6. The units of radioactivity are curie and Rutherford, One curie is how many Rutherfords? ....
7. Name of the breeder reactor in India is………………………………………………………………
8. Percentages of mass converted into energy in fusion and fission are…………………………………………
9. Cadmium is used in reactors as control rods, the functioning of D_2O in reactor is ………………………………………………
10. $_{92}U^{238}$ decays into $_{82}Pb^{206}$ by emitting α and β particles. The emitted α and β particles are in the ratio of…………………………
11. Forces between nucleons are F_{pp}, F_{pn}, F_{nn}. The relation between these forces when lie below 1fm and above 1fm distances are .... respectively.
12. The ratio between the strength of gravitational, electrostatic and nuclear forces is……………………………………………….
13. The spins of electron, photon, neutron and k-mesons are..respectively
14. A positronium is a combination of .... particles.
15. Critical mass of the fuel in reactor means…………………………………………………………………………….
16. The artificial fuel material in nuclear reactor is…..
17. Average Kinetic energy of thermal neutrons in the order of….. eV.
18. The process responsible for the source of stellar energy is……………………………………………………
19. The ratio between the Mass of the k-meson to the π-meson…………………………………………………
20. What is the ratio of density of nucleus to the water…………………………………
21. The energy released in annihilation of an electron .... MeV
22. $_{92}U^{235}$ and $_{26}Fe^{56}$ are Unstable and stable nuclei, Then the sign of Packing fraction values are… .... respectively.
23. In C-N cycle how many protons are involved to produce helium nucleus……………………………………
24. 1 amu =… .... joule
25. In binding energy curve maximum average binding energy and minimum average binding energy nuclei are……………………………
26. $_{92}U^{235} + {}_0n^1 \rightarrow X + Y +$ Energy, what is X , Y and energy?
27. Atomic bomb and Hydrogen bombs works on the principles of ………………………………………………………………………respectively.
28. Nuclear reactor works on the principle of ……………………………………………………………………………

29. BARC stands for…………………………………………………………………….
30. Atoms which have same excess number of neutrons over the protons is called……………………….....
31. The man made element produced in the first nuclear reactor is……………………….

❖ True or False Questions

1. The ratio of two nuclei atomic weights A and B is 27:64. Then the ratio of radius of A and B is 4:3
2. Find the wrong statement. Nuclear forces are
   (a) Spin dependent
   (b) Charge dependent
   (c) Short range and strongest
   (d) Arise due to exchange of π-meson
3. Find the wrong equation.
   (a) $p \rightarrow n + \pi^+$
   (b) $p \rightarrow p + \pi^0$
   (c) $n \rightarrow p + \pi^-$
   (d) $n \rightarrow n + \pi^+$
4. Find the wrong sentence.
   (a) Ionization power of α-particle is higher than β and ϒ.
   (b) Penetrating power of ϒ- particle is lower than β and α.
   (c) The velocity of α-particle is lower than β and ϒ.
   (d) ϒ-ray travel with the velocity of light.
5. Average energy released per each nucleon of $_{92}U^{235}$ is 200 MeV.
6. Nuclear fission occurs at higher temperatures; however fusion occurs even at room temperature.
7. According Bohr wheeler theory, heavier nuclei will take the shape of dumbbell before fission.
8. If the mass of the nuclei is very small, it can escape from the nuclear reaction.
9. Breeder reactor produces more fissile fuel than it consumes.
10. Photon, graviton has self-antiparticles.
11. The density of the nucleus increases with increasing A of the nuclei.
12. Heavy water is used as moderator in Breeder reactors.
13. Neutrons are required to start fission; however protons are generally required to start fusion.
14. Choose the correct sentence, Nuclear fusion is possible at
    (a) Higher temperature and Higher pressure
    (b) Higher temperature and lower pressure
    (c) Only at Higher temperature
    (d) Only at Higher pressure
15. C-N cycle happens at higher temperatures; however P-P cycle happens even at even at lower temperature.

16. Find the Correct statement, According to Yukawa nuclear force arcing due to
    (a) Exchange of k-mesons
    (b) Exchange of π-mesons
    (c) Exchange of proton and neutron
    (d) Exchange of antiparticle
17. Find the Correct statement, Binding energy curve drawn between
    (a) Binding energy versus mass number
    (b) Binding energy versus atomic number
    (c) Average binding energy versus mass number
    (d) Average binding energy versus atomic number
18. The great stability of nucleus is mainly consequence of the pairing off of the two protons and two neutrons with opposite spins.
19. Find the wrong statement, the nucleus contains
    (a) Even number of protons and neutrons is most abundant and most stable
    (b) Odd number of protons and neutrons is least stable
    (c) Either protons or neutrons is odd are the intermediately stable
    (d) Either protons or neutrons is even are the intermediately stable
20. When nuclei emit a α-particle or β particle, it is converted to other nuclei as per the Soddy-Fajan's displacement law.
21. Atoms having large disintegration constant are short lives.
22. Uranium-238 provides radioactive clock for geologists as carbon-14 for anthropologists.
23. Protons are not emitted by any radioactive substances.
24. For every antiproton in the universe there is a proton.
25. Find the correct statement, Fusion takes place at high temperature due to
    (a) Atoms are ionized at higher temperature
    (b) Molecules break up at higher temperature
    (c) Nuclei break up at higher temperature
    (d) KE is high enough to overcome repulsion between nuclei
26. Find the wrong statement, when nuclei emits ϒ-rays
    (a) neutron to proton ratio remains constant
    (b) The nuclear stability remains same
    (c) Position in the periodic table remains same
    (d) Its mass and atomic number remains same
27. Find the correct statement, The half-life period
    (a) Depends on initial quantity
    (b) Independent on initial quantity
    (c) Independent on disintegration
    (d) Independent nature

28. Find the wrong sentence, The atom consisting of
   (a) Large amount of empty space
   (b) Nucleons around the nucleus
   (c) Electrons around nucleus
   (d) Totally empty space
29. Find the wrong sentence, On the binding energy curve
   (a) Average binding energy is constant in the range 30<A<170
   (b) Very low average binding energy in A<10
   (c) Very high average binding energy in A>240
   (d) Maximum average binding energy at A=56
30. Find the correct sentence, Energy released
   (a) In fission, because BE per nucleon is larger in fission fragments than initial heavy nuclei
   (b) In fusion, because BE of heavy nuclei is larger than the total BE of lighter nuclei
   (c) Both A and B are wrong (d) Both A and B are correct
31. α- ray cannot cause ionization in gases
32. β-ray is stream of electrons organized from the nuclei during the nuclear transformation.

➢ Multiple choice questions Level-I

1. The shape of the nucleus is spherical because of
   (a) Surface tension (b) That shape provides maximum short range binding force
   (c) It is easier to form (d) The attraction between nucleons and electrons
2. The radius of atom is how many times larger than the radius of nucleus
   (a) 10^3 (b) 10^4 (c) 10^{-4} (d) 10^{-3}
3. The ratio between volume of the nucleus to the atom
   (a) 10^{14} (b) 10^{-14} (c) 10^{12} (d) 10^{-12}
4. Number of electrons in an atom is equal to half of the atomic weight is not valid in
   (a) He (b) Li (c) H (c) Be
5. Atomic Number represents
   (a) No of protons (b) No of neutrons (c) No of nucleons (d) All above
6. Discovery of neutron involves the bombardment of $_2He^4$ with
   (a) C (b) B (c) Be (d) N
7. Mass of the proton is
   (a) m_H-m_e (b) m_H+m_e (c) m_H (d) m_e
8. Free neutron is
   (a) Stable inside nucleus (b) Unstable
   (c) Decay into proton, electron and antineutrino (d) All above
9. Neutron is a neutral nucleon, what is its mean lifetime?
   (a) 4000sec (b) 3500sec (c) 1000sec (d) Infinite
10. Identify the artificial isotope of Hydrogen
   (a) $_1H^1$ (b) $_1H^2$ (c) $_1H^3$ (d) All above
11. Which one has chemically identical behaviour?
   (a) $_1H^1$, $_1H^2$ (b) $_2He^4$, $_3Li^6$ (c) $_7N^{15}$, $_8O^{15}$ (d) $_6C^{14}$, $_7N^{14}$
12. The pair of $_1H^3$, $_2He^3$ and $_6C^{13}$, $_7N^{13}$ are the
   (a) Isotopes (b) Isotones (c) Isodiapheres (d) Mirror nuclei

13. Electrons are held in atoms by
(a) Nuclear force (b) Vander waal's force (c) Electrostatic force (d) Gravitational force

14. The rest energies of photon and proton
(a) 0MeV, 938MeV (b) 0MeV, 0MeV (c) 1.02MeV, Infinite (d) 940MeV, 940MeV

15. The required amount of energies to create pair of proton, antiproton and electron, positron
(a) 1.02MeV, 4000MeV (b) 4000MeV, 1.02MeV (c) 1.02MeV, 1.02MeV (d) 4000MeV, 4000MeV

16. An electron revolves in the nth orbit of radius R, then its deBroglie wavelength
(a) $\pi R/n$ (b) $3\pi R/2n$ (c) $2\pi R/n$ (d) $4\pi R/n$

17. α-ray scattering experiment by Rutherford showed that
(a) No charged particle inside the atom (b) The atom as a whole is positively charged
(c) The atom consists of uniformly distributed positive and negative spheres
(d) The atom has a tiny, positively charged core at its centre

18. Rutherford, Geiger and Marsden's results on α-ray scattering suggested that
(a) Neutrons existed in the nucleus
(b) Electrons formed a hard, impenetrable shell around nucleus
(c) The positive charges in the nucleus uniformly distributed throughout the atom
(d) An extremely small, centrally located positive charged nucleus.

19. Particles which can be added to a nucleus without changing its chemical properties are
(a) Protons (b) electrons (c) neutrons (d) α-particle

20. The total angular momentum of a nucleus is due to
(a) Spin momenta of protons and neutrons only
(b) Orbital momenta of protons and neutrons only
(c) Spin and orbital momenta of protons and neutrons
(d) Neither spin nor orbital momenta protons and neutrons

21. The increasing order of strength of gravitational, electrostatic and nuclear force is
(a) Nuclear force, electrostatic force, gravitational force
(b) Nuclear force, gravitational force, electrostatic force
(c) Gravitational force, Nuclear force, electrostatic force
(d) Gravitational force, electrostatic force, Nuclear force

22. Nuclear forces arises due to exchange of
(a) photons (b) protons (c)π- mesons (d) positrons

23. Two nucleons can attract each other when they are apart
(a) 1Å (b) 1nm (c) 2 Fermi (d) less than 1 Fermi

24. According to conservation of momentum the two ϒ-rays move in opposite direction. Which of the following forces do not obey inverse square law?
(a) Gravitational (b) Electrostatic (c) Nuclear (d) Magnetic

25. Suppose a proton is completely converted into energy, the amount of energy produced will be
(a) 931MeV (b) 9×10^{20} eV (c) 6.61×10^{34} eV (d) 9×10^{10} eV

26. Which quantity remains constant, when mass number A increases?
(a) Density of nuclei (b) volume (c) binding energy (d) None of these

27. A radioactive nucleus with mass number A splits into two nuclei, whose mass numbers are in the Ratio of 8:5, then the ratio of radii of the nuclei is
(a) 5:8 (b) 8:5 (c) 2:5 (d) $2:5^{2/3}$

28. If M, m_p, m_n are the masses of the nucleus, proton, neutron and A, Z, N represents the mass number, proton number and neutron number, Then the binding energy will be

(a) BE= $[Zm_p + (A+Z) m_n + M]C^2$ (b) BE= $[Zm_p + (A-Z) m_n - M] C^2$

(c) BE= $[Zm_n + (A+Z) m_p]C$ (d) BE= $[Zm_n + (A-Z) m_p]C^3$

29. Energy liberated in a nuclear fission of 0.5 kg of uranium is

(a) 3×10^{16} J (b) 9×10^{16} J (c) 4.5×10^{16} J (d) 4.5×10^{15} J

30. The average binding energy per nucleon of nuclei is

(a) 8 eV (b) 8 keV (c) 8 MeV (d) 8 meV

31. The graph of $\log(R/R_0)$ verses log A is

(a) Straight line (b) parabola (c) hyperbola (d) ellipse

32. When a neutron of sufficient energy strikes a heavy fissionable element, two or more elements are released together with release of two or more additional neutrons. This is because of

(a) momentum of neutrons is very large

(b) neutron is electrically neutral particle

(c) neutron-proton ratio increases as mass number of element increases

(d) None of these

33. Which quantity remains constant in a nuclear reaction?

(a) Charge, momentum (b) momentum, mass

(c) mass, charge (d) Charge, momentum and parity

34. The more rapidly fissionable isotope of uranium has mass number of

(a) 234 (b) 235 (c) 238 (d) 236

35. In a nuclear fission the percentage of mass converted into energy is about

(a) 0.01% (b) 0.1% (c) 1% (d) 10%

36. India's first nuclear reactor is

(a) apsara (b) param padh (c) Brahmos (d) avathar

37. The fissionable material used in Nagasaki bomb attack is

(a) plutonium (b) neptunium (c) uranium (d) berkelium

38. ${}_1H^1 + {}_1H^1 + {}_1H^2 \rightarrow {}_2He^4 + {}_1e^0 + E$ is possible at

(a) high temperature and high pressure (b) high temperature and low pressure

(c) low temperature and high pressure (d) low temperature and low pressure

39. If two nuclei of masses m_1 and m_2 fuse to form a nucleus of mass M, then

(a) $m_1 + m_2 = M$ (b) $m_1 - m_2 = M$ (c) $(m_1 + m_2) > M$ (d) $(m_1 + m_2) < M$

40. In a nuclear reaction a nucleus is converted into another with the emission of a positron. Then The neutron to proton ratio

(a) Will increase (b) will decrease (c) remains constant (d) always unity

41. The binding energies of atoms of two elements A and B are E_A and E_B respectively. In a reaction, Three atoms of element B fuse to give one atom of A and energy Q. Then

(a) $E_A + E_B + Q = 0$ (b) $E_A = 3 E_B$ (c) $3 E_B = E_A + Q$ (d) $E_B = 3 E_A$

42. The half life of radioactive substance depend on

(a) pressure (b) temperature (c) Nature of substance (d) all the above

43. α and β particles cause ionization, because of
(a) Photoelectric emission (b) pair production
(c) Compton collision (d) electrostatic force

44. If the decay constant of a radioactive element is λ. The half life and mean life of the element are
(a) 1/λ and $\log_e 2/\lambda$ (b) $\log_e 2/\lambda$ and 1/λ (c) 1/λ and $\log_e 2/\lambda$ (d) λ/ $\log_e 2$ and λ

45. What percentage of original radioactive atoms is left after 3 half lives?
(a) 3% (b) 12.5 % (c) 8% (d) 15%

46. Certain types of cancer can be cured by
(a) radio-cobalt (b) radio-iron (c) radio-carbon (d) radio-iodine

47. The action of heart can be investigated using radioactive
(a) Fe-59 (b) I-131 (c) Ir-192 (d) Cr-51

48. Binding energy per nucleon is maximum at A=56 and its value is around
(a) 8 MeV (b) 8.7 MeV (c) 9 MeV (d) 7.8 MeV

49. The ascending order of ionization power of α, β and ϒ particles
(a) α, β, ϒ (b) ϒ, β, α (c) α, ϒ, β (d) β, α, ϒ

50. The one has maximum radioactive activity
(a) Uranium (b) Plutonium (c) Radium (d) Thorium

51. The number of neutrons that are released on an average during the fission of uranium
(a) 3 (b) 2.5 (c) 1 (d) 4

52. The average KE of thermal neutrons is of the order of
(a) 3.0 KeV (b) 0.03 KeV (c) 0.3 KeV (d) 0.003 KeV

53. Positronium is converted into
(a) 2 photons each of energy 0.51 MeV (b) 1 photon of energy 1.02 MeV
(c) 2 photons each of energy 1.02 MeV (d) 1 photon of energy 0.51 MeV

54. The energy released when neutron breaks into proton and electron.
(a) 0.73 MeV (b) 7.10 MeV (c) 6.30 MeV (d) 5.4 MeV

55. If nucleus Al^{27} has nuclear radius of 3.6 fm. then Te^{125} would have its radius around
(a) 9.6 fm (b) 6 fm (c) 4.8 fm (d) 12 fm

56. The thermions are
(a) protons (b) photons (c) electrons (d) positrons

57. The mass of π-meson is not added or subtracted from that of proton or neutron is based on
(a) conservation of mass (b) conservation of energy
(c) Uncertainty principle (d) All the above

58. Find out the magic numbers.
(a) 6, 28 (b) 50, 82 (c) 18, 20 (d) 120, 126

59. The following reaction: ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1$ is called
(a) Fusion (b) fission (c) α-decay (c) β-decay

60. Packing fraction of nuclei is
(a) (M-A)/A (b) (A-M)/A (c) (M-A)/M (d) (M+A)/A

61. Surface energy of the nucleus is proportional to the parameter (A) as
(a) A (b) A^3 (c) $A^{1/3}$ (d) $A^{2/3}$

62. The initial rise of binding energy curve mainly due to

(a) Decreasing the importance of surface energy

(b) Decreasing the importance of coulomb energy

(c) Increasing the importance of surface energy

(d) Increasing the importance of coulomb energy

63. The method used to measure the half-lives ranging from 10 to 10^{18} years

(a) Mechanical method (b) Direct method (c) Weighing method (d) none of the above

64. Radioactive clock for anthropologists is

(a) C^{12} (b) C^{14} (c) U^{235} (d) U^{238}

65. Fission occurs due to involvement of

(a) Fast neutrons (b) Thermal neutrons (c) High energy neutrons (d) All above

66. 1 Becquerel equal to

(a) 1dps (b) 3.7×10^{10} dps (c) 10^{10} dps (d) 3.7×10^{8} dps

67. If m_p= 1.0073 amu, m_n= 1.0087amu and mass of α-particle is 4.0015 amu, what is the binding energy of α-particle

(a) 28.41 MeV (b) 24.81 MeV (c) 21.84 MeV (d) 82.41 MeV

68. The BE per nucleon for deuterium and helium are 1.1 MeV and 7.0 MeV, the energy released when 10^6 deuterons take part in the reaction.

(a) 18.88 μ J (b) 1.888 μ J (c) 188.8 μ J (d) 1888 μ J

69. The set represent the isotope, isobar and isotone respectively

(a) ($_1H^2$, $_1H^3$), ($_{79}Au^{197}$, $_{80}Hg^{198}$), ($_2He^3$, $_1H^2$) (b) ($_1H^2$, $_1H^3$), ($_{79}Au^{199}$, $_{80}Hg^{198}$), ($_2He^3$, $_1H^2$)

(c) ($_1H^2$, $_1H^3$), ($_{79}Au^{198}$, $_{80}Hg^{198}$), ($_2He^3$, $_1H^2$) (d) ($_1H^2$, $_1H^3$), ($_{79}Au^{196}$, $_{80}Hg^{197}$), ($_2He^3$, $_1H^2$)

70. The number of beta particles emitted by material is twice the number of alpha particles emitted by it. The resulted daughter is

(a) Isotope of parent (b) isobar of parent (c) isotone of parent (d) isomer of parent

71. Heavy stable nuclei have more neutrons than protons due do fact that

(a) neutrons are heavier than protons

(b) to provide more attractive strong nuclear force to balance repulsive electrostatic force

(c) neutrons decay into protons through beta decay

(d) nuclear forces between neutrons are weaker than that of protons

72. During mean life of radioactive element the fraction that disintegrates is

(a) e (b) 1/e (c) 1-(1/e) (d) e/(e-1)

73. A nucleus undergoes ϒ- decay due to

(a) excess of protons (b) excess of neutrons (c) excess of mass (d) its excited state

74. The ratio of nuclear radii and nuclear densities of $_{26}Fe^{56}$ and $_{92}U^{238}$ is

(a) 0.671 and 1 respectively (b) 1 and 0.671 respectively

(c) both are equal to 1 (d) both are equal to 0.671

75. In a sample off radioactive substance, what percentage decays in one mean life is

(a) 70% (b) 64% (c) 50% (d) 45%

76. The decay constant of the end product of nuclei is

(a) Zero (b) One (c) infinite (d) As same as initial

77. The fraction of radioactive substance that remains after n decays is equal to
(a) 2/n (b) n/2 (c) 2^n (d) $1/2^n$

78. The constancy of binding energy per nucleon due to
(a) Larger nuclear force than columbic force
(b) The nuclear force between p-p, p-n and n-n is same
(c) Nuclear force falls to zero as their distance is more than 2fm
(d) All above

79. The shape of radioactive decay curve
(a) linear (b) exponential (c) straight line (d) saw-tooth

80. Moderator in APSARA reactor is
(a) Graphite (b) Heavy water (c) Water (d) all the above

81. In which country, damage of nuclear reactors occurred in 2011
(a) USSR (b) America (c) Japan (d) India(tamilnadu)

82. Nuclear forces are stronger than electromagnetic and gravitational forces provided the separation between the interacting nucleons is within the range.
(a) 10fm (b) 1fm or less (c) 100fm (d) several micrometers

83. In light nuclei the neutron number and proton number tend to be equal, because
(a) Nuclear forces between the nucleons are much dominant over the coulombic repulsion
(b) Coulomb repulsion is much stronger
(c) Nuclear forces and coulomb repulsion are equal in magnitude
(d) Nuclear forces are weak

84. Nuclear stability is accomplished if there are more number of neutrons than that of protons, because
(a) neutrons do not participate in coulomb interaction
(b) protons do not take part in coulomb interaction
(c) neutrons actively participate in coulomb interaction
(d) protons and neutrons take part in coulomb interaction

➢ Multiple choice Questions Level-II

1. In an atom bomb, a temperature of 10MK is developed at the instant of explosion. In hot region of the spectrum, the wavelength corresponds to maximum energy lies in
(a) X-ray (b) UV (c) Visible (d) IR

2. $_{92}U^{235}$ emits 5α, 6β and 7 ϒ particles, then the atomic number and atomic weight of the daughter nuclei will be
(a) 88, 225 (b) 87, 274 (c) 109, 252 (d) 88, 215

3. The half life of a radioactive element is 1600 min. The fraction of a sample that would remain after 6400 min is
(a) 1/2 (b)1/4 (c) 1/8 (d) 1/1

4. The radioactivity in any nucleus is measured in curie and Becquerel, the relation between these Units will be
(a) $1Ci = 3.7\times10^7$ Bq (b) $1Bq = 3.7\times10^7$ Ci (c) $1Ci = 3.7\times10^{10}$ Bq (d) $1Ci = 10^6$ Bq

5. A radioactive nuclide can decay simultaneously by two different processes which have decay constants λ_1 and λ_2. The effective decay constant of the nuclide is λ.

(a) $\lambda = \lambda_1 + \lambda_2$ (b) $\lambda = (\lambda_1 + \lambda_2)/2$ (c) $\lambda = (\lambda_1 + \lambda_2)^{-1}$ (d) $\lambda = \lambda_1\lambda_2$

6. A nucleus splits into two nuclear parts having radii in the ratio 1:2. Their velocities are in the ratio of

(a) 8:1 (b) 6:1 (c) 4:1 (d) 2:1

7. The energy required to separate the typical middle mass nucleus $_{50}Sn^{120}$ into its constituents Nucleons (The mass of Sn is 119.902199amu, m_p= 1.007825amu and m_n = 1.008665amu).

(a) 951 MeV (b) 805 MeV (c) 1021 MeV (d) 1212 MeV

8. In nuclear fission, 0.1% mass is converted into energy. The energy released in the fission of 1kg

(a) 2.5MKWH (b) 25MKWH (c) 250MKWH (d) 0.25MKWH

9. The binding energy per nucleon of C^{12} is 7.68 MeV and that of C^{13} is 7.47 MeV. The energy required to remove one neutron from C^{13} is

(a) 495 MeV (b) 49.5 MeV (c) 4.95 MeV (d) 0.495 MeV

10. The atomic mass of N^{15} is 15.000108amu and that of O^{16} is 15.994915amu. The minimum energy required to remove the least tightly bound proton is (m_p is 1.007825amu)

(a) 0.013018 amu (b) 1.213 MeV (c) 13.018 MeV (d) 12.13 MeV

11. The decay constant of a radioactive element, which disintegrates to 10gms from 20gms in 10 minutes is

(a) 0.693 (b) 6.93 (c) 0.693 (d) 0.0693

12. Half life period of radium is 1600 years. 2 gm of radium undergoes decay and gets reduced to 0.125 gms in

(a) 3200 years (b) 25600 years (c) 8000 years (d) 6400 years

13. A radioactive sample has 2×10^{20} active nuclei at a certain instant of time. Then the number of samples in the same active state after three half-lives is

(a) 2.5×10^{15} (b) 2.5×10^{21} (c) 2.5×10^{19} (d) 2.5×10^{16}

14. If the activity of Ag is 3μCi, the number of atoms present in it are (λ= 0.005sec^{-1})

(a) 2.2×10^{7} (b) 2.2×10^{6} (c) 2.2×10^{5} (d) 2.2×10^{4}

15. A radioactive isotope having a half life of 3 days was received after 9 days. It was found that there was only 4 gms of the isotope in the container. The initial weight of the isotope when packed was

(a) 8 gms (b) 64 gms (c) 48 gms (d) 32 gms

16. The half life period of Pb^{210} is 22 years. If 2gram of Pb is taken, then the amount of Pb will be after 11 years.

(a) 0.1414 g (b) 1.414 g (c) 2.828 g (d) 0.707 g

17. When $_{92}U^{235}$ undergoes fission. About 0.1% of the original mass is converted into energy. Then the amount of $_{92}U^{235}$ should undergo fission per day in a nuclear reactor so that it provides energy of 200 mega watt electric power is

(a) 9.6×10^{-2} kg (b) 4.8×10^{-2} kg (c) 19.2×10^{-2} kg (d) 1.2×10^{-2} kg

18. In nuclear fusion, one gram hydrogen is converted into 0.993 gm. If the efficiency of the generator be 5%, then the energy obtained in KWH is

(a) 8.75×10^3 (b) 4.75×10^3 (c) 5.75×10^3 (d) 3.73×10^3

19. A photon of energy 1.12 MeV splits into electron and positron pair. The velocity of electron is

(a) 3×10^8 m/s (b) 1.32×10^8 m/s (c) 6×10^8 m/s (d) 9×10^8 m/s

20. 50% of radioactive substance decays in 5 hours. The required time for 87.5% decay is

(a) 10hous (b) 15hours (c) 12.5hours (d) 17.5hours

21. 4 gram of radioactive substance A left 0.5 gram after sometime. 1 gram of another substance B left 0.25 gram in the same period. If half life of B is 2 hours, then the half life of A is

(a) 3/4 hours (b) 4/3 hours (c) 1/4 hours (d) 1/2 hours

22. 3 rutherfords of a radioactive isotope of half-life equal to 3 days, was received after 12 days. Then the initial isotope packed was

(a) 48 rutherford (b) 12 rutherford (c) 25 rutherford (d) 36 rutherford

23. The half-life of a radioactive substance is 6 hours. The amount of the substance undergone disintegration when 36 gram of it undergoes decay for 18 hours is

(a)31.5 gm (b) 4.5 gm (c) 18 gm (d) 9 gm

24. 20% of a radioactive element disintegrates in 1 hour. The percentage of the radioactive element disintegrated in 2 hours will be

(a) 36% (b) 64% (c) 60% (d) 40%

25. The C^{14} to C^{12} ratio in a certain piece of wood is 25% of that in atmosphere. The half-life period of C^{14} is 5580 years. The age of wood piece is

(a) 5580 years (b) 2790 years (c) 1395 years (d) 11160 years

26. The age of the wood if only 1/16 part of original C^{14} is present in the piece is (half life time of C^{14} is 5580 years)

(a) 5580 years (b) 11160 years (c) 22320 years (d) 16740 years

27. Equal masses of two samples A and B of charcoal are burnt and the activity of resulting CO_2 from two samples is measured. The gas from sample A gives 10^4 counts per month and that from sample B gives 2.5×10^3 counts per month. The age difference of two samples is (half life of C^{14} is 5730 years)

(a) 5730 years (b) 11460 years (c) 17190 years (d) 22920 years

28. A sample of radioactive material has mass m, decay constant λ, and molecular weight W, Avogadro constant is N, Then the activity of the sample after time t is

(a) $(mN/M)\, e^{-\lambda t}$ (b) $(mN\lambda/M)\, e^{-\lambda t}$ (c) $(mN/M\lambda)\, e^{-\lambda t}$ (d) $m/\lambda(1- e^{-\lambda t})$

29. The fraction of radioactive sample will decay during half of its half-life period is

(a) $1/\sqrt{2}$ (b) $1/(\sqrt{2}-1)$ (c) $1-1/\sqrt{2}$ (d) ½

30. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q value of the reaction is 5.5 MeV, then the KE of α-particle?

(a) 4.4 MeV (b) 5.4 MeV (c) 5.6 MeV (d) 6.5 MeV

31. After 280days, the activity of a radioactive sample is 600dps. The activity reduces to 300dps after another 140 days, the initial activity of the sample in dps is

(a) 5000 (b) 9000 (c) 3000 (d) 24000

32. The binding energies per nucleon for Deuterium and helium are 1.1 MeV and 7.0 MeV. The energy in joules will be liberated when 10^6 deuterons take part n the reaction

(a) 18.88×10^{-3} J (b) 18.88×10^{-5} J (c) 18.88×10^{-7} J (d) 18.88×10^{-10} J

33. The mass of neutron and protons are 1.008665amu, 1.007276 amu. If the difference of the masses of a neutron and proton is 'n' times the mass of an electron, the value of 'n' is around

(a) 1 (b) 2 (c) 2.5 (d) 1837

34. How much mass is lost per day by a nuclear reactor operated at 900 MW power level. If each fission releases 200 MeV, how many fissions occur per second to yield this power?

(a) 2.812×10^{19} (b) 28.12×10^{19} (c) 281.2×10^{19} (d) 0.2812×10^{19}

35. In a nuclear fusion of conversion of hydrogen into helium the lost in mass is 0.7%. How much energy released when 1 kg of hydrogen is converted into helium.

(a) 6.3×10^{19} J (b) 6.3×10^{14} J (c) 3.6×10^{14} J (d) 3.6×10^{19} J

36. The C-N cycle protons are fused to form a helium nucleus, positrons and energy also released. The number of protons fused and the number of positrons released in this process will be

(a) 4, 4 (b) 4, 2 (c) 2, 4 (d) 4, 6

37. The binding energy of ${}_{92}U^{238}$ is around (mass of ${}_{92}U^{238}$ is 238.050783amu, m_p=1.007825amu and m_n=1.008665amu)

(a) 1801 eV (b) 1800 MeV (c) 18.01 MeV (d) 1.02 MeV

38. The binding energies per nucleon for deuterium and α-particles are E_1 and E_2. What will be the energy released in the reaction ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + E$

(a) $2(E_2 - E_1)$ (b) $4(E_2 - E_1)$ (c) $E_2 - E_1$ (d) $E_2 + E_1$

39. A heavy nucleus having mass number 200 gets disintegrated into two fragments of mass number 80 and 120. If the BE per nucleon for parent is 6.5 MeV and for daughters is 7 MeV and 8 MeV respectively. Then the energy released in the process will be

(a) 220 MeV (b) 2000 MeV (c) 220 eV (d) 7.5 MeV

40. In electron positron pair annihilation process, If the rest mass of electron is 0.5 MeV and the total KE of pair is 0.78 MeV, Then the energy of gamma ray must be

(a) 1.78 MeV (b) 1.28 MeV (c) 0.78 MeV (d) 1.02 MeV

41. The energy released in the process ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$ is (BE per nucleon for deuterium and helium are 1.1 MeV and 7 MeV)

(a) 23.6 MeV (b) 25 MeV (c) 30 MeV (d) 36.4 MeV

42. The temperature at which the reaction may initiate ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4$ (the average energy between two nuclei is 7.7×10^{-14} J and K=1.38×10^{-23} J/K)

(a) 10^6 K (b) 10^7 K (c) 10^8 K (d) 10^9 K

43. What is the output power of ${}_{92}U^{235}$ reactor, if it takes 30days to use 2 kg of fuel? Energy released per fission is 200 MeV, N= 6.023×10^{26} per kilo mole.

(a) 63.28 MW (b) 3.28 MeV (c) 5.6 KeV (d) 6.3 MeV

44. The released energy in the fission of ${}_{92}U^{235}$ is 200 MeV, the number of fissions required per second to produce 1KW power is

(a) 3.125×10^{13} (b) 3.125×10^{14} (c) 3.125×10^{15} (d) 3.125×10^{16}

45. A mixture consists of two radioactive materials A_1 and A_2 with half-lives of 20s and 10s respectively. Initially the mixture has 40g of A_1 and 106g of A_2. The amount of the two in the mixture will become equal after

(a) 40s (b) 60s (c) 80s (d) 20s

46. Two radioactive materials A and B have decay constants 13/7 and 19/14 units respectively. Initially both have same number of nuclei. The time after which the ratio of their remaining nuclei will be 1/e is

(a) 2s (b) 3s (c) 4s (d) 5s

47. A sample contains 10^3 kg each of two nuclear species A and B with half-life 4 days and 8 days respectively. The ration of the amounts of A and B after a period of 16 days is

(a) 1:2 (b) 1:4 (c) 4:1 (d) 2:1

48. Half-lives for α and β emission of a material are 16 years and 48 years respectively. When material decays giving α and β emissions simultaneously, time in which ¾ material decays is

(a) 12 years (b) 24 years (c) 36 years (d) 6 years

49. Half-lives of two isotopes X and Y of material re known to be 2×10^9 years and 4×10^9 years. If planet was with equal number of these isotopes, then the current age of planet is (Currently material has 20% of X and 80% of Y)

(a) 2×10^9 years (b) 4×10^9 years (c) 6×10^9 years (d) 8×10^9 years

50. For a radioactive sample the counting rate changes from 6520 counts/min to 3260 counts/min in 2 minutes. What is the decay constant?

(a) 5.78×10^{-3}/sec (b) 6.58×10^{-3}/sec (c) 2.78×10^{-3}/sec (d) 0.347×10^{-3}/sec

51. After 150 days, the activity of a radioactive sample is 5000 dps. The activity becomes 2500 dps after another 75 days. The initial activity of the sample is

(a) 20000 dps (b) 10000 dps (c) 5000 dps (d) 40000 dps

52. Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be 1/e after a time

(a) $1/10\lambda$ (b) $2/9\lambda$ (c) $1/9\lambda$ (d) $11/10\lambda$

53. The half-life of a radioactive isotope 'X' is 50 years. It decays to another element 'Y' which is stable. The two elements 'X' and 'Y were found to be in the ratio of 1:15 in a sample of a given rock. The age of the rock was estimated to be

(a) 100 years (b) 150 years (c) 200 years (d) 250 years

54. One gram of a radioactive sample of half-life 10 min is sealed in a capsule at time t=0. Amount of sample decayed up to 5 min is

(a) 0.293g (b) 0.392g (c) 0.5g (d) 0.75g

55. Two radioactive substances A and B have decay constants 5λ and λ respectively. At t=0 they have the same number of nuclei. The ratio of number of nuclei of A to those of B will be $1/e^2$ after a time interval

(a) 2λ (b) 4λ (c) $1/2\lambda$ (d) $1/4\lambda$

56. The half-life of radioactive Radon is 3.8 days. The time at the end of which $1/20^{th}$ of the radon sample will remain un-decayed is (given loge=0.4343)

(a) 3.5 days (b) 16.5 days (c) 14.5 days (d) 12 days

57. Average life of a radioactive sample is 4ms. Initially the total number of nuclei is N_0, A charged capacitor of capacity 20μF is connected across a resistor R. The value of R such that ratio of number of nuclei remaining to charge on capacitor remains constant with time is

(a) 400Ω (b) 300Ω (c) 200Ω (d) 100Ω

58. In α -decay the kinetic energy of α-particle is 48 MeV and Q-value of the reaction is 50 MeV. The mass number of the mother nucleus is (Assume that daughter nucleus is in ground state)

(a) 95 (b) 92 (c) 100 (d) 104

59. Starting with a sample Cu^{66}, 7/8 of pure decays into Zn in 15 minutes. The half-life is

(a) 5 minutes (b) 10 minutes (c) 15 minutes (d) 20 minutes

60. The count rate from a radioactive sample falls from 4.0×10^6 per second to 1×10^6 per second in 20 hour. What will be the count rate, 100 hour after the beginning?

(a) 3.91×10^3 sec−1 (b) 5.91×10^3 sec−1 (c) 9.31×10^3 sec−1 (d) 3.91×10^4 sec−1

61. The speed of daughter nuclei is

(a) $C\,(2\Delta m/M)^2$ (b) $C\,(2\Delta m/M)^{1/2}$ (c) $2C\,(\Delta m/2M)^2$ (d) $C\,(\Delta m/2M)^{1/2}$

62. The half-life time of radium is 1600 years. How much time does 1gram of radium take o reduce 0.125g

(a) 1600 years (b) 3200 years (c) 4800 years (d) 6400 years

63. A radioactive isotope has half-life time of 5000 years. How long will it take the activity reduces to 1% of its mass.

(a) 250000 years (b) 33250 years (c) 45000 years (d) 18000 years

64. Why is a ϒ-rays rather than β and α source is injected into a patient as a medical tracer to monitor tumors in the body.

(a) ϒ-rays does not ionize where as β and α cannot be detected outside the body

(b) ϒ-rays does not penetrate where as β and α cannot be detected outside the body

(c) ϒ-rays do not harmful where as β and α- are harmful

(d) ϒ-rays does not ionize and penetrate where as β and α may ionize and penetrate

➢ Match the followings

1.

(A). Electron	(P). Anderson
(B). Proton	(Q). Chadwick
(C). Neutron	(R). Thomson
(D). Positron	(S). Rutherford

2.

(A). I^{131}	(P). Anemia
(B). Na^{24}	(Q). Kinetics plants Photosynthesis
(C). C^{14}	(R). Blood clots
(D). Fe^{59}	(S). Thyroid gland

3.	(A). Isotopes	(P). Neutrons
	(B). Isotones	(Q). Atomic mass
	(C). Isobars	(R). Protons
	(D). Isomers	(S). Neutrons and Protons

4.	(A). 1.67×10^{-27} kg	(P). Neutron
	(B). 9.1×10^{-31} kg	(Q). Photon
	(C). Zero kg	(R). Proton
	(D). 1.68×10^{-27} kg	(S). Electron

5.	(A). $K=0$	(P). Accelerated
	(B). $K=1$	(Q). Retarded
	(C). $K<1$	(R). Stop
	(D). $K>1$	(S). Equilibrium

6.	(A). Thorium	(P). $_{83}Bi^{209}$
	(B). Neptunium	(Q). $_{82}Pb^{206}$
	(C). Actinium	(R). $_{82}Pb^{207}$
	(D). Uranium	(S). $_{82}Pb^{208}$

7.	(A). 4n	(P). $_{89}Ac^{227}$
	(B). 4n+1	(Q). $_{92}U^{238}$
	(C). 4n+2	(R). $_{90}^{Th232}$
	(D). 4n+3	(S). $_{93}Np^{237}$

8.	(A). Zero	(P). $_{26}Fe^{56}$
	(B). Above Zero	(Q). $_{92}U^{235}$
	(C). Below Zero	(R). $_{6}C^{12}$
	(D). very high	(S). $_{2}He^{4}$

9.	(A). Gravitons	(P). Electromagnetic Interaction
	(B). Photons	(Q). Weak interaction in nuclei
	(C). Leptons	(R). Gravitational interaction
	(D). Hadrons	(S). Strong interaction in nuclei

10.	(A). Photoelectric effect	(P). Ejection of electron from higher shell
	(B). Compton effect	(Q). Low energy and high Z
	(C). Pair production	(R). Medium energy and low Z
	(D). Auger effect	(S). High energy and high Z

11.	(A). Moderator	(P). Absorption of neutrons
	(B). Control rods	(Q). Absorption of heat
	(C). Radiation shielding	(R). Prevention of Radiation exposure to outside
	(D). Coolant	(S). Slow down neutrons

12.	(A). Half-lifetime	(P). (M-A)/A
	(B). Average life time	(Q). 0.693/λ
	(C). Mass defect	(R). Mass of the nucleons – M
	(D).Packing fraction	(S). 1/λ

13.	(A). α	(P). Z-1 and A-4
	(B). β	(Q). Z-0 and A-0
	(C). ϒ	(R). Z+1 and A-0
	(D). α and β	(S). Z-2 and A-4

14.	(A). Penetrating power	(P). 0.1: 0.3: 1.0
	(B). Ionization ratio(α, β, ϒ)	(Q). 1000:100:1
	(C). Kinetic energy	(R). α>β>ϒ
	(D). velocity ratio (α, β, ϒ)	(S). α<β<ϒ

15.	(A). Nuclear fission	(P). photons
	(B). Nuclear fusion	(Q). neutrons
	(C). Pair production	(R). protons
	(D). Photoelectric effect	(S). ϒ-ray

KEY AND HINTS

❖ One word answer Questions

Q.NO	ANSWER	HINT	HAVE TO DO ADDTIONALLY
1	$1837 \times m_e$	-	Masses of all particles, in different units also
2	1:8	$R = R_0 A^{1/3}$	Check radius if mass number known and ratios
3	Isotope,Isobar,Isotone	-	Properties of these and isomers, isodiaphere, mirror nuclei etc.
4	Fermi	-	Other small units in terms of meter
5	A, B,C	-	Stability dependence parameters
6	1 Ci = 3.7×10^{10}Bq	-	Other units of activity and their relations
7	Dhruva	-	Famous reactors in India/world and specifications
8	0.7% and 0.1%	-	Usage of Einstein relation of mass conversion
9	Moderator	-	Functioning of elements in reactors with examples
10	8α, 6β	-	α, β and ϒ-Decay and their properties
11	$F_{PP}=F_{PN}=F_{NN}$ below 1fm $F_{PP}<F_{PN}=F_{NN}$ above 1fm	-	Properties of nuclear forces compare to other forces also
12	$F_g: F_e: F_n = 1: 10^{36}: 10^{38}$	-	Forces and their strength, ranges, quantum particles in it
13	1/2, 1, 1/2, 0	-	Elementary particles and their basic properties
14	Electron and positron	-	Antiparticles of others and their combination energies
15	Minimum mass of the fuel to continue chain reaction	-	Conditions for reaction and effect of other parameters on reaction
16	$_{94}Pu^{239}$	-	Other fuels and efficiency of reactance
17	0.03eV	-	Thermal neutrons ,fast neutrons and properties
18	Nuclear fusion	-	Fission and H-H, C-N cycle differences
19	966:270	-	Masses of other particles compare with electron
20	10^{14}:1		Density dependence/independence parameters
21	0.51MeV	-	Annihilation energies of particles and antiparticles
22	Positive, negative	-	Packing fraction and significance
23	4 protons	-	Compare H-H cycle with energies also
24	1.49×10^{-10} J	-	amu in different terms of energies, $E=Mc^2$ conversions
25	$_{26}Fe^{56}$, $_1H^1$	-	Binding energy curve and its importance
26	$_{53}Ba^{141}$, $_{36}Kr^{92}$,200MeV	-	Fission, fusion reactions and differences
27	Nuclear fission, fusion	-	Chain reaction, principle of bomb blasting energy
28	Controlled chain reaction	-	Working of reactor
29	Bhaba atomic research centre	-	Nuclear research institutes in India and world
30	Isodiapheres	-	Difference between Isotones and diapheres
31	Plutonium	-	Significance of it, where it used in the world war

❖ True/ False Questions

Q.NO	ANSWER	HINT	HAVE TO DO ADDITIONALLY
1	False	$R= R_0 A^{1/3}$	Have to practice more problems on this formula
2	b	-	Properties of nuclear forces
3	d	$n \rightarrow n + \pi^0$	Yukawa π-meson exchange, charge conserve
4	b	-	Properties of α, β and ϒ-particles
5	False	0.83 MeV	Observe energy in fission and fusion, for each nucleon
6	True	-	Conditions for occurrence of reactions H-H, C-N cycle
7	True	-	Bohr wheeler theory for fission
8	True	-	Critical mass and conditions for fission
9	True	-	Functioning of breeder reactor
10	True	-	Antiparticle of other particles
11	False	-	Properties of nucleus
12	False	-	Difference between reactor, breeder reactor
13	True	-	Fission, fusion starting conditions and released energy
14	a	-	Condition for fusion and fission
15	False	Both are at high, but lesser temperature in H-H cycle	H-H cycle occurrence compared to C-N cycle
16	b	-	Yukawa exchange for stability
17	c	-	Binding energy curve and importance of curve
18	True	-	Stability dependence parameters
19	d	-	Binding energy, pairing of nucleons dependence
20	True	-	Decay laws and Soddy- Fajan's displacement law.
21	True	-	Mean life, average life dependence of λ
22	True	-	Applications of other Isotopes
23	True	-	Decay laws and final products
24	True	-	Antiparticles of other particles
25	d	-	Effect of temperature on nuclei
26	b	-	α, β and ϒ-particles decay effects of parent nuclei
27	b	-	Half life dependence parameters
28	d	-	Properties of atom and nucleus
29	c	-	Binding energy curve and its importance
30	d	-	Fusion, fission energies comparison
31	True	-	Expect cause of ionization
32	True	-	B-decay

❖ Multiple choice questions Level-I

Q.NO	ANSWER	HINT	HAVE TO DO ADDITIONALLY
1	b	-	Why nucleus is in stable, nucleons
2	b	-	Radius of nuclei, atom, its units and relations
3	b	-	Sizes of atom, nuclei, dependence on R,A
4	c	-	Electron, proton, neutrons calculation of nuclei
5	a	-	Z, A calculations
6	c	-	Equation ,discovery of neutron and properties
7	a	-	Masses of particles
8	d	-	Properties of neutron, thermal and fast neutrons
9	c	-	Lifetime of other nucleon during degradation
10	c	-	Other artificial isotopes and importance
11	a	-	Reason for identical behaviour
12	d	-	Other mirror nuclei examples
13	c	-	Other forces and ranges
14	a	-	Compare other particle energies if exist
15	b	-	Annihilation $E=Mc^2$ law applications
16	c	-	DeBroglie wavelength
17	d	-	Experimental results of α-scattering
18	d	-	α-scattering results other parameters
19	c	-	Reasons for alteration of properties by adding other
20	c	-	Spin ,orbital angular momentum
21	d	$F_g: F_e: F_n = 1: 10^{36}: 10^{38}$	Origin of these forces and ranges
22	c	-	Yukawa theory
23	d	-	If distance beyond that what happens
24	c	-	Inverse square law and conditions
25	a	-	Is it really possible, why not verify
26	a	-	Relation of volume, density, and radius
27	None	$2:5^{1/3}$	$R= R_0 A^{1/3}$ calculate other nuclei examples
28	b	-	Mass defect, BE, stability influence
29	c	-	$E=Mc^2$ convert other masses and energy
30	c	-	Binding energy curve importance, consequences
31	a	-	Find intercept parameter, compare decay graph
32	c	-	Verification n/p ratio in case of other particles
33	d	-	Verify other parameter in fission, fusion
34	b	-	233,238 have peculiarity, identify
35	b	-	Compare fusion
36	a	-	Other reactors in India, famous reactors, hazards
37	a	-	Hiroshima Nagasaki incidents atomic, hydrogen bomb
38	a	-	Conditions for fission, fusion
39	c	-	Expect mass convert into energy, compare to fission
40	a	-	Guess emission of other particles from nuclei
41	c	-	Mass defect conversion into energy
42	c	-	Factors influence the mean life

43	d	-	Ionization factors in α, β, ϒ particles
44	b	-	Relation between mean, half life, some problems
45	b	Logical think half life	Other half life times remaining, decay products
46	a	-	Applications of other isotopes in all fields
47	b	-	Applications of other isotopes in all fields
48	b	-	Importance of binding energy curve, consequences
49	b	-	Properties of α, β, ϒ-rays, velocity, ionization relation
50	b	-	Others fuels activity, peculiarity of this element
51	b	-	Fission reaction, fusion, mother & daughters
52	b	-	Fast neutrons energies, not involved fission, reason
53	a	-	Annihilation, energy
54	a	$E=\Delta m\ C^2$	Mass defect energy, conversion of other reaction E
55	b	$R= R_0\ A^{1/3}$	Estimate other elements radius for compare
56	c	-	Thermionic emissions
57	c	-	Why could not added uncertainty principle apply
58	b	-	Significance of magic numbers
59	a	-	Fusion, fission difference
60	a	-	Packing fraction, significance, stability
61	d	-	Surface energy, semi-empirical formula
62	a	-	Binding energy curve lower region
63	c	-	Weighing method calculation
64	b	Carbon-dating	Geologist element and application
65	b	-	Properties of thermal neutrons
66	a	-	Other units and relations
67	a	$E=\Delta m\ C^2$	Estimate in fission
68	B	BE differences	Estimate other cases such as varied no of particles
69	c	-	Isomer, mirror nuclei, isodiaphere
70	a	-	α, β, ϒ decay rules
71	b	-	Expect lighter nuclei what happened
72	c	$1-N/N_0$	What about half life time fraction
73	d	-	Expect when α, β decay and changes than ϒ-decay
74	a	$R= R_0\ A^{1/3}$ & d is constant	Calculate other elements
75	b	$N_0(1-e^{-\lambda t})$	Expect in half-life time
76	a	$dN/dt=0$	Expect λ variation with time
77	d	-	Calculate Decayed sample after n decays
78	d	-	Binding energy curve importance, nuclear force
79	b	-	Equation comparison, initial position on line
80	c	-	Parts in a reactor and its functioning
81	c	-	Tsunami incident in Japan 11 reactors damage
82	b	-	Expect if distance increases what happened
83	a	-	Check influence on stability of N=P nucleus
84	a	-	Expect why coulombic force doesn't exist between neutrons

❖ Multiple choice questions Level-II

Q.NO	ANSWER	HINT	HAVE TO DO ADDITIONALLY
1	a	$\lambda T=b$	Check other temperatures expect region of spectra
2	d	-	α, β, ϒ-decay
3	c	n=4, $1/2^n$	Calculate reaming, left samples with n varied examples
4	c	-	Radioactivity units and relations
5	a	-	Expect lifetime formula for this combination
6	a	$M_1/M_2=(R_1/R_2)^3=V_2/V_1$	Varying mass ratio, velocities findings
7	c	BE= $\Delta m \times 931.5\ MeV$	Calculate in fission
8	b	E= $m\ C^2$	Calculate different percentages of mass energies
9	c	Difference in BE	Estimate other conversions
10	d	$\Delta m = mp + mn - mo$,	Estimate other conversions energies
11	d	$\lambda=0.693/T_{1/2}$, 20 to 10gram means $T_{1/2}$	Calculate λ for other conversions from 100 to 25 etc
12	d	n =4, $T= n\times T_{1/2}$	Estimate for 1 gram in the same problem and n varied
13	c	$N/2^n$	Calculate after 4, 5 half lifetimes
14	a	Activity =λ N	Calculate N for different value of A and λ
15	d	$N_0=N2^n$, n=9/3	Calculate other values of problem with n changing way
16	b	$N_0=N2^n$, n=0.5	Develop Logical thinking without doing for this
17	c	$M=E/C^2$, E=PT	Calculate M for other power values, and mass used %
18	a	Remaining mass=0.007g, E= $m\ C^2$,convert to KWH	Use different problems mass conversion, efficiency %, energy in joules also
19	b	$E= (1/2mv^2)2 + 2mC^2$	Check the velocity of daughter nuclei formula
20	b	n =3,	Logical think to solve
21	b	$N=N_0e^{-\lambda t}$, $\lambda=0.693/T_{1/2}$, T finding same	Logical think to solve
22	a	$N_0=N2^n$, n=12/3	Try to calculate back calculation from options
23	a	n =3, decayed=(1-1/8)36	Logical think, estimate remaining
24	a	Logical	Don't confuse disintegrated, and remaining in logical way
25	d	$N=N_0e^{-\lambda t}$, $\lambda=0.693/T_{1/2}$	If ratio 50% expect age of the wood
26	c	n =4, T=4×half life	Logical way
27	b	$N_1/N_2=e^{-\lambda(t2-t1)}$, $\lambda=0.693/ T_{1/2}$	If have age difference find λ
28	b	-	-
29	c	$N/N_0=(1/2)^{t/T}$, t=T/2, $(N_0-N)/N_0$	-
30	b	$E=P^2/2m$, conservation of momentum, $M_\alpha E_\alpha=M_xE_x$	Calculate if β particle emits
31	d	$2^n\times600$,n=2, $T_{1/2}=140$	Logical think enough
32	c	BE difference	Estimate other cases such as varied no of particles
33	c	-	-
34	a	3.1×10^{10} fission produce 1watt	$M=Pt/c^2$ mass calculation, No of fissions=Power/energy, cross check it
35	b	$E=MC^2$	Check other percentages

36	b	-	Check in H-H cycle also
37	b	-	Check packing fraction also
38	b	-	Observe conservation of energy
39	a	$E=BE_{daughter}- BE_{parent}$	Check in fission reaction
40	a	$\Upsilon \rightarrow e + e^{+} + KE$	Check annihilation of ϒ-ray energy
41	a	$E=4\times7-2\times2\times1.1$	Convert in joule
42	d	$E=(3/2)KT+(3/2)KT$	Check wiens law
43	a	E for 1amu=200MeV/235 Calculate for 2Kg(convert amu to Kg), then convert E into power	Check if energy released is 185MeV
44	a	$P=nE/t$	Calculate for 2KW, 3KW etc
45	a	Back calculation	Logical think
46	a	$N_a/N_b=1/e$	Check for $1/e^2$
47	b	$N_a=N_o(1/2)^n$ n=16/4 for a $N_b=N_o(1/2)^n$ n=8/4 for b Then N_a/ N_b	Check for 32 days
48	b	$\lambda =\lambda_1+\lambda_2$, $N/N_o=1/4$	Check back calculation
49	d	$N_a/N_b=0.2/0.8=e^{t(\lambda 2-\lambda 1)}$	Check for 50:50 ratio
50	a	$N=N_0e^{-\lambda t}$	Logical think λ=0.693/2, check for other time, N/No ratio
51	a	Logical think	Check for after another 75 days activity
52	c	$N_a/N_b=1/e$	Check for $1/e^2$, $1/e^3$ and check for another λ_1, λ_2
53	c	$N_X/N_Y=1/15$, $N_X/N_{Total}=1/16=1/2^4$,n=4 then age =4×half life	Check for ratio of 1:31 and 1:63 for the same problem
54	a	$N=N_0e^{-\lambda t}$	Estimate sample at 7minutes
55	c	$N_a/N_b=1/e^2$	Check for $1/e^2$, Check for $1/e^3$, Check for 1/e
56	b	$\lambda =0.693/T_{1/2}$, $N=N_0e^{-\lambda t}$	Check for 1/10 of the material same problem
57	c	$N=N_0e^{-\lambda t}$, $Q=Q_0e^{-t/RC}$,N/Q constant leads $\lambda=1/RC$	Check for another C for the same
58	c	$K_\alpha=M_yQ/(M_y+M_\alpha)$, $K_\alpha= (A-4)Q/A$	Find Q when A and K_α given in the same problem
59	a	Remaining=$1/8=1/2^3$ n =3, 15=3T	Check for 15/16 of deacy
60	a	$T_{1/2}=10$,	Logical enough or λ calculation as usual also calculate
61	b	$\Delta mC^2=1/2(M/2)V^2+1/2(M/2)V^2$	-
62	c	$N_o/N =8$, then n =3, $T=3\times T_{1/2}$	Calculate time o become 0.0625g
63	b	$N/N_0=1\%$	Calculate time for 3.125% reduce.
64	a	-	Properties of α, β, ϒ rays in application way

❖ Match the followings

Q.NO	ANSWER			
1	*A-R*	*B-S*	*C-Q*	*D-P*
2	*A-S*	*B-R*	*C-Q*	*D-P*
3	*A-R*	*B-P*	*C-Q*	*D-S*
4	*A-R*	*B-S*	*C-Q*	*D-P*
5	*A-R*	*B-S*	*C-Q*	*D-P*
6	*A-S*	*B-P*	*C-R*	*D-Q*
7	*A-R*	*B-S*	*C-Q*	*D-P*
8	*A-R*	*B-Q*	*C-P*	*D-S*
9	*A-R*	*B-P*	*C-Q*	*D-S*
10	*A-Q*	*B-R*	*C-S*	*D-P*
11	*A-S*	*B-P*	*C-R*	*D-Q*
12	*A-Q*	*B-S*	*C-R*	*D-P*
13	*A-S*	*B-R*	*C-Q*	*D-P*
14	*A-S*	*B-Q*	*C-R*	*D-P*
15	*A-Q*	*B-R*	*C-S*	*D-P*

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15 - SEMI CONDUCTOR ELECTRONICS
MATERIALS, DEVICES & SIMPLE CIRCUITS

Synopsis :

- **Conductors** are the substances in which free electrons move randomly Ex : Copper, Silver

  Resistivity (P) : 10^{-2} to 10^{-8} Ω m

  Conductivity (σ) : 10^{2} to 10^{8} Sm^{-1}
- **Insulators** are the substance in which electrons are tightly bound to nucleus. Ex: Wood, Glass, Rubber

  Resistivity (P) : 10^{11} to 10^{19} Ω m

  Conductivity (σ) : 10^{-11} to 10^{-19} Sm^{-1}
- **Semi Conductors** are the substance which are intermediate between conductors and insulators. Ex: Si, Ge, cds, GaAs

  Resistivity (P) : 10^{-5} to 10^{6} Ω m

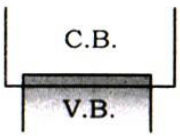
  Conductivity (σ) : 10^{5} to 10^{-6} Sm^{-1}

- **Valance Band :** The energy band which includes the energy levels of valance electrons is called Valance Band.

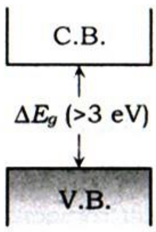
- The Energy band above the valance band is called Conduction Band

- **For bidden Energy Gap :** The Energy gap between conduction band and Valance band is called For bidden energy gap.

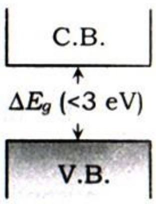
- The Highest energy level which an electron can occupy at ok is called FERMI ENERGY LEVEL.



Conductors



Insulators



Semi Conductors

- Semi Conductors are two types :
  1. Intrinisic Semi conductors
  2. Extrinsic Semi conductors

- **Intrinisic Semi conductors :** Semi conductors in their pure form are called intrinisic semi conductors. Ex : Si, Ge
- The no of free electrons is equal to no of holes.

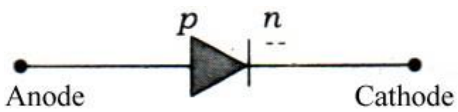
- Low conductivity

- **Extrinsic Semi conductors :** An impurity is added to intrinisic semi conductor is called extrinisic semi conductor.
  They are two types i) P-type ii) N-type

- **P-type semi conductor :** Trivalent substance like Boron, aluminium, Gallium, Indium are doped in a pure Semi conductor.
- Acceptor

- **N-type semi conductor :** Pentavalent substance like Nitrogen, Phosphorous, Arsenic are doped to a pure semi conductor.
- Donor Impurity

- **P-N Junction Diode :** A P-N Junction is formed by doping N-type on one side and P-type on the other side of a pure semi conductor.



- **Forward Biaring of Diode :** In forward biasing P-region is connected to positive terminal of a battery and n-regions is connected to negative terminal of a battery.

- The current will be of order of milli amperes (mA)

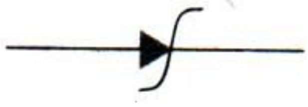
- **Reverse biasing of P-N Juncttion diode :** In Reverse bias P-region is connected to negative terminal of a battery and N-region is connected to a positive terminal of a battery.
- Current will be in the order of Micro amperes (μA)

- **Rectifier :** Conversion of A.C. Voltage into D.C. Voltage is called rectifier. They are two types.
- **Half Wave Rectifier :** The Rectifier in which only alternate half cycles of applied alternating signal are converted into direct current is known as Half – Wave rectifier
- One diode is used
- Efficency ɱ = $\frac{0.406R_L}{r_f+R_L}$
  Maximum Efficiency = 40.6 %

- **Full Wave rectifier :** The rectifier in which whole cycle of applied alternating signal is converted into direct current
- Two diodes are used.
- Efficency ɱ = $\frac{0.812R_L}{r_f+R_L}$
- ɱ=81.2 %

Zener Diode :

- A heavily doped P-n junction diode which is operated in the breakdown region in reverse bias
- Zener diode acted as a voltage regulator.



Light Emitting Diode : It is a heavily doped P-n junction in the forward bias emits spontaneous radiation that comesout from a transparent cover.

- **Photo diode :** It is a reverse biased P-N junction diode provided with transparent window to allow light to fall in it.
- **LED :** Is a heavily doped P-N junction in the forward bias emits spontaneous radiation that comesout from transparent cover.
- **A Solar Cell :** Is a P-n junction which generates e.m.f when solar radiation falls on it.

- **Transistor :** It transfer resistance
- Current operated device
- It consists of three parts 1) Emitter 2) Base 3) Collector.

- **Emitter :** It is heavily doped. It provides majority charge carriers by which current flows in the transistor.

- **Base (B) :** Base region is lightly doped and thin.

- **Collector (C) :** The size of collector region is larger than the other regions. This is moderately doped.

There are two types of transistors.

- **i) Npn - Transistors :** when two segments of n-type semi conductor are separated by P-type semi conductor.
- **ii) Pnp Transistors :** when two segments of P-type semi conductor are separated by n-type semi conductor.

In PNP transistor holes are majority charge carriers.

Relation Between $\propto$ and β :

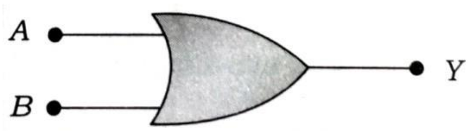
i) $\propto = \frac{\beta}{1+\beta}$ ii) $\beta = \frac{\propto}{1-\propto}$

Amplifier : It increase the strength of oscillations.

Logic Gates :

OR Gate : It has atleast two inputs and only one output (Y)

Output expression : Y=A+B



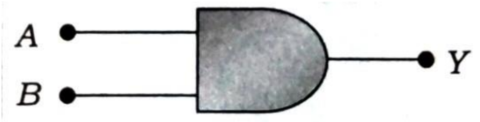
Logical symbol of OR gate

Truth Table

A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

AND Gate : It has atleast two inputs and only one output (Y)

Output expression : Y= A.B



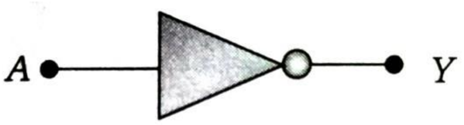
Logical symbol of AND gate

Truth Table

A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1

NOT Gate : It has only one input and only one output

Output expression : Y= $\bar{A}$



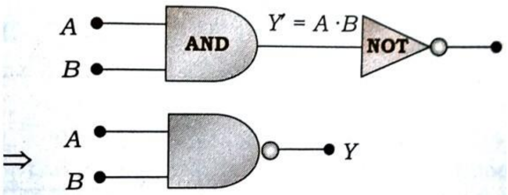
Logical symbol of NOT gate

Truth Table

A	Y= $\bar{A}$
0	1
1	0

NAND Gate : It has atleast two inputs and only one output

Output expression : Y= $\overline{A.B}$



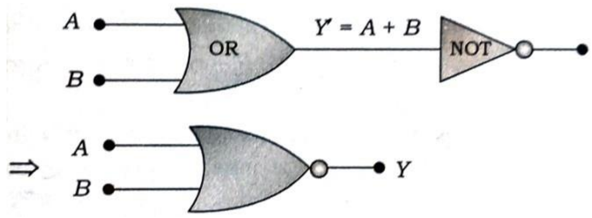
Truth Table

A	B	Y = A.B	Y
0	0	0	1
0	1	0	1

1	0	0	1
1	1	1	0

NOR Gate : It has atleast two inputs and only one output (Y)

Output expression : Y= $\overline{A+B}$

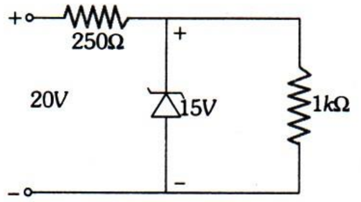


Truth Table

A	B	Y = A+B	Y
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

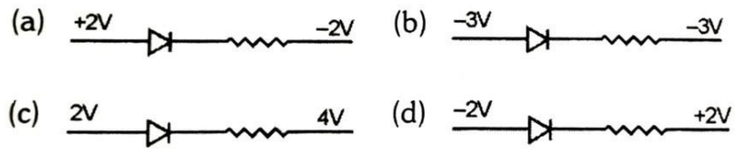
PART-I :- ONE WORD ANSWER QUESTIONS

1. What are majority charge carriers in P-type Semi conductor ?
2. When the electrical conductivity of a semi conductor is due to breaking of its covalent bands, then the semi conductor called ?
3. Let 'n_h' and 'n_e' in the no. of holes and electrons respectively. Then what in the relation between intrinsic and N-type semi conductor?
4. What happened to the resistance when the temperature increase of a intrinsic semi conductor.
5. What are trivalent and pentavalent impurities ? Give example ?
6. What are the energy gaps in Ge and Si in eV ?
7. In a P-type semi conductor, the acceptor impurity produces as energy level located at ?
8. The contribution in the total current flowing through a semi conductor due to electrons and holes are ¾ and ¼ respectively if the drift velocity of electrons in $\frac{5}{2}$ times that of holes at this temperature, then the ratio of concentration of electrons and holes is ?
9. What is hole ?
10. Define forward bias of a P-n junction diode ?
11. When forward bias is applied to a P-N junction then what happened to the potential banner, and width of the charge depleted region ?
12. What are the maximum efficiency of half wave and full wave rectifiers ?
13. The value of DC voltage in half wave rectifier in converting A.C. Voltage V=100 Sin (314t) into D.C. is ?
14. A Zener diode having breakdown voltage equal to 15v, used as voltage regulator circuit shown in figure. The current through the Diode is



15. Consider the junction diode an ideal. The value of current flowing through 'AB' in

16.16.



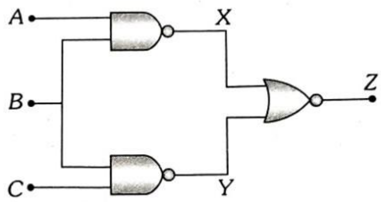
Which diodes forward Bias and which diodes reverse Bias ?

17. The emitter – base junction of a transistor is.....................biased while the collector – base junction in.................biased ?

18. For a transistor the parameter β= 99 then the value of the parameter '∝' is ?

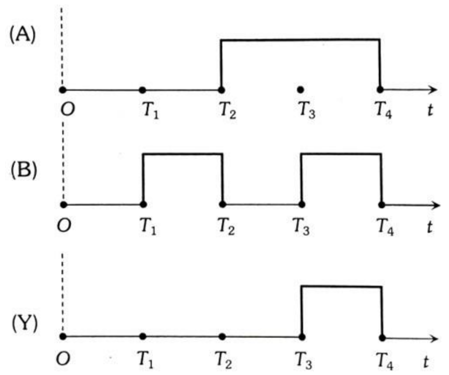
19. In a transistor if collector current in 25 mA and base current is 1 mA, then the amplification factor '∝' is ?

20.20.

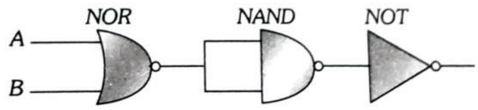


The figure show two NAND gates follow by a NOR gate. The system is equivalent to the which logic gate ?

21.21.



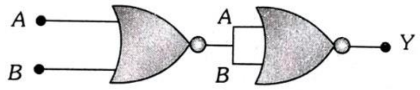
22.The figure show the waveforms for two inputs A and B and that for the input Y ofa logic circuit. The logic circuit is ?



The circuit in equal to ?

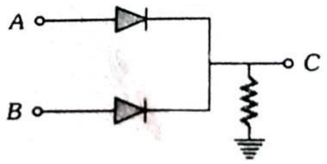
22. The logic gates giving output 'I' for the inputs of 'I' and 'O' ?

23.24.



Draw the truth table for this circuit ?

24.25.



In the circuit A and B represents two inputs and C represents the output, the circuit represents ?

25. Which logic gates called universal logic gates ?

Multiple Choice Question (Part-II)

1. The valency of the impurity atom that in to be added germanium crystal so as to make it a N-type semi conductor is

   a) 6 b) 5 c) 4 d) 3

2. Which of the following material in the best conductor of electricity ?

   a) Platinum b) Gold c) Silicon d) Copper

3. A hole in a P-type semi conductor is ?

   a) An Excess of electron b) A missing electron
   c) A missing atom d) A donor level

4. In a semi conductor ?

   a) There are no free electron at any temp
   b) The no of free electrons in more than in a conductor
   c) There are no free electrons at $0^{o}K$ d) None of these

5. The forbidden energy bond gap in conductors, semi conductors and insulators are EG_1, EG_2, EG_3, respectively. The relation among them

   a) $EG_1 = EG_2 = EG_3$ b) $EG_1 < EG_2 < EG_3$
   c) $EG_1 > EG_2 > EG_3$ d) $EG_1 < EG_2 < EG_3$

6. A piece of copper and other of germanium are cooled from the room temper to 80 K, then which of the following in correct statement ?

   a) Resistance of each increases
   b) Resistance of each decreases
   c) Resistance of copper increases while germanium decreases
   d) Resistance of copper increases while that of germanium increases

7. A PN Junction Diode in used as

   a) An amplifier b) A rectifier c) An oscilator d) A modulator

8. On adjusting the P-N Junction diode in forward brased.

a) Depletion layer increase b) Resistance increase

c) Both decreases d) None

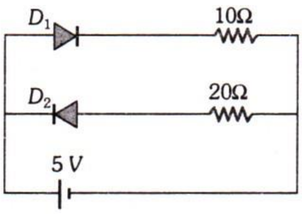
9. On increasing the reverse bias to a large value in a P-N Junction diode current.

a) Increase slowly b) Remains fired

c) Sudden increase d) Decreases slowly

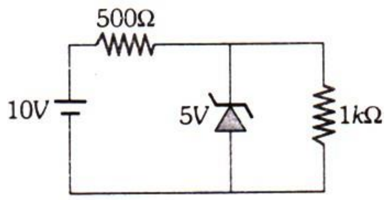
10. Two ideal diodes are connected to a battery as shown in the circuit. The current supplied by battery in

a) 0.75 A B) Zero c) 0.25A d) 0.5A

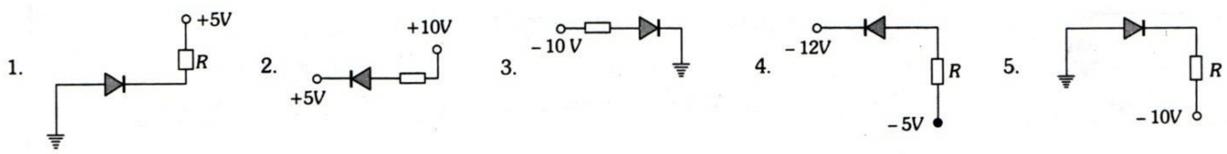


11. In the following circuit, the current flowing through 1 KV resistor is

a) o ma b) 5 ma c) 10 ma d) 0.5 A

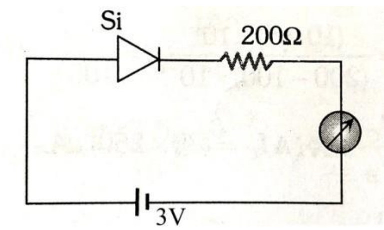


12. In the given figure, which of the diodes are forward biased



a) 1,2,3 b) 2,4,5 c) 1,3,4 d) 2,3,4

13.13.



The reading of the ammeter for a silicon diode in the given circuit.

a) 11.5 ma b) 13.5 ma c) 0 d) 15 ma

14. if l_1, l_2, l_3 and the length of the emitter, base, emd collector of a transistor then

a) $l_1 = l_2 = l_3$ b) $l_3 < l_2 < l_1$ c) $l_3 < l_1 < l_2$ d) $l_3 > l_1 > l_2$

15. For transformer action

a) Base, emitter and collector regions should have similer size and doping concentrations

b) The base region must be very thin and lightly doped

c) The emitter – Base junction is forward biased and base – collector junction is reverse biased

d) Both the emitter – base junction as well as the base collector junction and forward biased

16. In a common base amplifier the phase difference between the input signal voltage and the output voltage in

a) 0 b) $\pi/4$ c) $\pi/2$ d) π

17. For a transformer, the current ratio $\propto_{dc} = \frac{69}{70}$. The current gain β_{dc} in

a) 66 b) 67 c) 69 d) 71

18. The phase difference input and output voltage of a CE circuit in

a) 0 b) 90 c) 180 d) 270

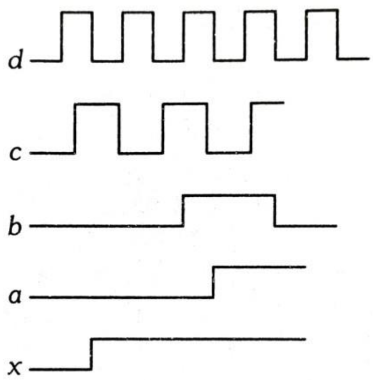
19. In a transistor in CE configuration, the ratio of power gain to voltage gain is

a) $\propto$ b) $\frac{\beta}{\propto}$ c) $\propto \beta$ d) β

20. In a P-n junction diode, change in temperature due to heating.

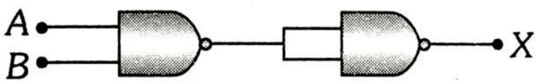
a) Affects only reverse resistance b) Affects only forward resistance
c) Does not affect resistance if P-n junction
d) Affects over all V-I charactesties of P-n Junction

21. If a,b,c,d and input to a gate and 'X' in the output, then as per the following time graph, the gates



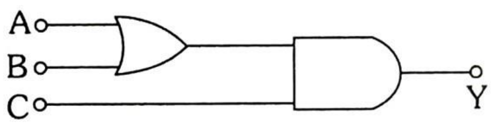
a) AND b) OR c) NAND d) NOT

22. The output (x) of the logic circuit shown in figure will be



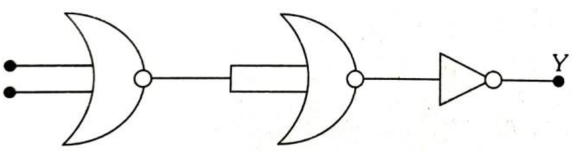
a) X= $\overline{A+B}$ b) X= $\overline{\overline{A}}\,.\,\overline{\overline{B}}$ c) X= $\overline{A.B}$ d) X= A .B

23. To get output 1 from the circuit shown in the figure, the input must be



a) A=0, B=1, C=0 b) A=1, B=0, C=0 c) A=1, B=0, C=1 d) A=1, B=1, C=0

24. The given electrical network in equivalent to to



a) AND gate b) or gate c) NOR gate d) NOT gate

ASSERTION & REASON (PART-II)

1. Assertion :- The large gate NOT can be built using diode.
   Reason :- The output voltage and the input voltage of diode have 180^0 phase difference
2. Assertion :- In a common emitter transistor amplifier the input Current is much less than the output current
   Reason :- The Common emitter transistor amplifier has very high input impedance.
3. Assertion :- If the temperature of a semi conductor is increased then its resistance decreases.
   Reason :- The energy gap between conduction band and valance band is very small.
4. Assertion :- Silicon is preferred over germanium for making semi conductor devices.
   Reason :- The energy gap for germanium is more than energy gap for silicon.
5. Assertion :- Two P-N junction diodes place back to back, will work as NPN transistor
   Reason :- The P-region of two PN junction diodes back to back Will form the base of NPN transistor
6. Assertion :- In transistor common emitter mode as an amplifier Is preferred over common base mode.
   Reason :- In common emitter mode the input signal is connected in series with the voltage applied to the base emitter junction.
7. Assertion :- NAND or NOR gates are called digital building blocks
   Reason :- The repeated one of NAND (or NOR) gates can produce all the basic or complicated gates.
8. Assertion :- The current gain in common base circuit is always less Than one.
   Reason :- At constant collector voltage the change in collector current is more than the change in emitter current.
9. Assertion :- Zener diode works on a principle of breakdown Voltage.
   Reason :- Current increases suddenly after breakdown voltage.

MATCHING :- (PART-IV)

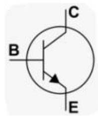
I.

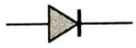
1) P-type semi conductor ( ) a) Si
2) N-type semi conductor ( ) b) Al
3) Intrinsic semi conductor ( ) c) Cu
4) Metal ( )d) As

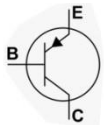
II.

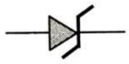
1) Si (or) Ge ( ) a) Holes
2) P-type semi conductor ( ) b) Electrons
3) N-type semi conductor ( ) c) Free electrons
4) Alkali Metals ( ) d) Holes and electrons

III.

1) Diode ( ) a) 

2) Zener Diode ( ) b) 

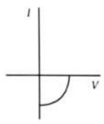
3) P-n-p transistor ( ) c) 

4) N-p-n transistor ( ) d) 

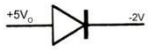
IV.

1) Diode ( ) a) Oscilator
2) Zener Diode ( ) b) Emf Source
3) Transistor ( ) c) Rectifier
4) Battery ( ) d) Voltage regulator

V.

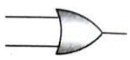
1) Diode ( ) a) 

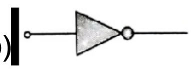
2) Photo Diode ( ) b) 

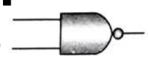
3) Solar cell ( ) c) 

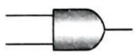
4) Forward Bias ( ) d) 

VI.

1) AND Gate ( ) a) 

2) OR gate ( ) b) 

3) NOT gate ( ) c) 

4) NAND gate ( ) d) 

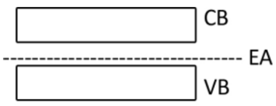
ANSWERS
PART-I

1. Majority charge carriers in P-type semi conductor : HOLES
2. Intrinsic semi conductors.
   - In intrinsic semi conductor, conductivity in due to the breaking of covalan bond
   - In extrinsic semi conductor, conductivity is due to the breaking of covalen bond and excess of charge carriers mainly due to impurity.
3. In intrinsic semi conductors $n_e = n_n$

   For N-type $n_e >>> n_n$
4. The resistance of intrinsic semi conductor decreases with increasing temperature
5. Trivalent impurities : B,Al, In, Ga, Th (IIIrd group elements)

   Pentz valent impurities : N, P, AS, Sb, Bi (V group elements)
6. Eg = 0.7 ev for GE

   Eg= 1.1 ev for Si
7. Just above the valance Band



8. 6:5

   Current I= neAVd

   $$\frac{I_e}{I_n} = \frac{n_e}{n_n} \times \frac{V_e}{V_n}$$

   $$\frac{3/4}{1/4} = \frac{n_e}{n_n} = \frac{5}{2}$$

   $$\frac{n_e}{n_n} = \frac{6}{5}$$
9. An electron vacancy
10. The P-side of a diode is connected to the positive terminal of the battery
11. In forward Bias, both V_B and width (x) decreases
12. In half wave rectifier n=40.6%

    For full wave rectifier n=81.2%
13. Vdc $= \frac{Vo}{\pi}$ (In half wave rectifier)

    $= \frac{100}{1x3.1463}$ = 31.84 volt
14. Current though 1 KV $I_L = \frac{15}{1x63}$ = 15 ma

    Current in the circuit I= 20-15 = 5 x 10^{-2} = 20 ma

15.V_{PN}= 4-(-6) = 10V Diode in forward bias I=

$\frac{10}{1x10^3}$ = 10^{-2}A

16. a) $V_{PN} = V_P - V_N =$ 2-(-2) = 4V (Forward Bias)

    b) $V_{PN} = V_P - V_N =$ -3-(-3) = 0 (No Biasing)

    c) $V_{PN} = V_P - V_P =$ 2- 4 = -2 (Reverse Bias)

    d) $V_{PN} = V_P - V_P =$ -2-(-2) = - 4 (Reverse Bias)
17. Emitter – Base Junction Forward Biased

    Collector – Base Junction Reverse Biased

18. Answer : - $\propto$ = 0.99

β= 99 $\quad \propto = \frac{\beta}{1+\beta} = \frac{99}{100}$ = 0.99

19. $\frac{25}{26}$

$\beta = \frac{I_C}{I_B} = \frac{25}{1}$

$\propto = \frac{\beta}{1+\beta} = \frac{25}{26}$

20. 'AND' Gate

X= $\overline{AB}$ Y= $\overline{BC}$ Z= $\overline{AB}$ + $\overline{BC}$ = $\overline{\overline{ABC}}$ = ABC

21. 'AND' Gate

Time Internal	A	B	Y
0 -> T_1	0	0	0
T_1->T_2	0	1	0
T_2->T_3	1	0	0
T_3->T_4	1	1	1

22. 'NOR' Gate

X= $\overline{A+B}$ Y= $\overline{\overline{A+B}}$ = A+B

Z= $\overline{A+B}$

23. 'NAND' gate and 'OR' gate

24.

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

25. 'OR' gate

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

26. 'NAND' and 'NOR' gates are called universal gates.

ANSWERS : MULTIPLE CHIOCE QUESTIONS : PART – II

1. b

In N-type semi conductor impurity that has to be added in Pentavelent (Valancy : 5)

2. d

Among the materials copper in the best conductor of Electricity

3. b

Vacancy of Electron is called Hole

4. c

At 0^{0}K semi conductor acts as a insulator.

5. b

(Eg) Conductor = 0, (Eg) Semi Conductor < 3ev, (Eg) Insulator > 3ev

6. d

As 'T' decrease P_{cu} decrease because relaxation time (T) decreases

As 'T' decrease P_{Ge} increase due to less no of free charge carrilrs

7. b

Diode in used to convert ac in to dc (rectifier)

8. c

Depletion layer and resistance decreases.

9. c

At a certain high reverse bias voltage current suddenly increased. This is called breakdown voltage.

10. d

D_1 in the biased (ON)and D_2 in reverse bias (OFF)

$$I = \frac{5}{10} = 0.5A$$

11. b

Voltage across 1 KΩ resistance = 5 V

$$I = \frac{5}{1x10^3} = 5 \text{ mA}$$

12. b

1) $V_{PN} = V_P - V_N$ = 0-5 = -5V (RB)

2) 2) $V_{PN} = V_P - V_N$ = 10-5 = 5V (FB)

3) $V_{PN} = V_P - V_N$ = -10- (-0) = -10 (RB)

4) $V_{PN} = V_P - V_N$ = -5- (-12) = 5V (FB)

5) $V_{PN} = V_P - V_N$ = 0-(-10) = 10 (FB)

13. a

Knee voltage of Si diode V_T=0.7 V

$$I = \frac{3-0.7}{200} = 11.5 \text{ mA}$$

14. d

Emitter has moderate size, base has thin size and collector has large size

15. c

In active state Emitter – Base Junction → FB

Collector – Base Junction → RB

As well as base region must be very thin and lightly doped.

16. a

In CB amplifier input and output signal are in same phase.

17. c

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}} = \frac{\frac{69}{70}}{1-69/70} = 69$$

18. c

19. d

Ap = Power Gain = β x Av (Voltage gain)

$$\frac{Power\ gain}{Voltage\ gain} = \beta$$

20. d

Affects overall V-I characteristics of P-n Junction

21. b

a	b	c	d	x
0	0	0	0	0
0	0	0	1	1
0	0	1	1	1

i.e. OR gate

22. b and d

Y= $\overline{A.B}$ X= $\overline{\overline{A.B}}$ = A.B

23. c

X= A+B Y= $(A+B)^C$ C≠0

24. c

P= $\overline{A+B}$ Q = A+B Y= $\overline{A+B}$ = Nor gate

ASSERTION & REASON ANSERS PART – 3

1. If the assertion and reason both are FALSE
In diode the output is in same phase with the input therefore it cannot be used to buclt NOT gate.
2. If assertion is True but reason is false.
In common emitter transistor amplifier current gain β>1, so output current > input current, hence assertion is correct.
Also, input circuit has low resistance due to forward biasing to emitter base junction, hence reason is false.
3. If both assertion and reason are true.
In semi conductors energy gap between conduction band and valance band is small-Due to temp rise, electron in the valance band gain thermal energy and may jump across the small energy gap. Thus conductivity increases and hence resistance decreases.
4. If Assertion is true but reason in false
The energy gap in germanium less (0.72 ev) than the energy gap in silicon (1.1 ev) therefore, silicon is preferred over germanium for making semi conductor device,
5. The assertion and reason both are false
Two P-N Junction placed back to back cannot work as transistor. Because in Transistor the worth and concentration of doping of P-Semi conductor is less as compared to width doping of N-type semi conductor type.
6. Both assertion and reason are true but reason is not the correct explanation of the assertion.
Common emitter is preferred over common base because all the current, voltage and power gain of common emitter amplifier is much more than the gains of common base amplifier.

7. Both assertion and reason are true.
These gates are called digital building blocks because using these gates only we can compile all other gates. (Like AND, OR, Not and X-or)

8. Assertion in true but reason is FALSE
The current gain in common base circuit $\propto = (\frac{\Delta I_C}{\Delta I_E})\ V_C$
The change in collector current is always less than the change in emitter circuit .
$\Delta I_C < \Delta I_E$ Therefore $\propto <1$

9. Assertion and reason are both one TRUE
When the reverse voltage across the Zenar diode is equal to or more than the breakdown voltage, the reverse current increases sharply.

MATCHING (Answers) PART-IV

I.
1. (b)
2. (d)
3. (a)
4. (c)

II.
1. (d)
2. (a)
3. (b)
4. (c)

III.
1. (b)
2. (d)
3. (a)
4. (c)

IV.

1. (c)
2. (d)
3. (a)
4. (b)

V.

1. (b)
2. (d)
3. (a)
4. (c)

VI.

1. (d)
2. (a)
3. (b)
4. (c)

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16.COMMUNICATION SYSTEMS

SYNOPSIS

Communication is the act of transmission of information. For communication to be successful, it is essential that the sender and receiver understand a common language.
modern communication system was developed by J.C. Bose, F.B. Morse, G. Marconi and Alexander Graham Bell.

VARIOUS FORMS OF COMMUNICATION

Telegraph, Radio broadcasting, Television, Telephony, RADAR, SONAR, email, Fax, Mobile phones, Teleprinting etc.

THREE ELEMENTS OF COMMUNICATION SYSTEM

Every communication system has three essential elements.

1. Transmitter: -

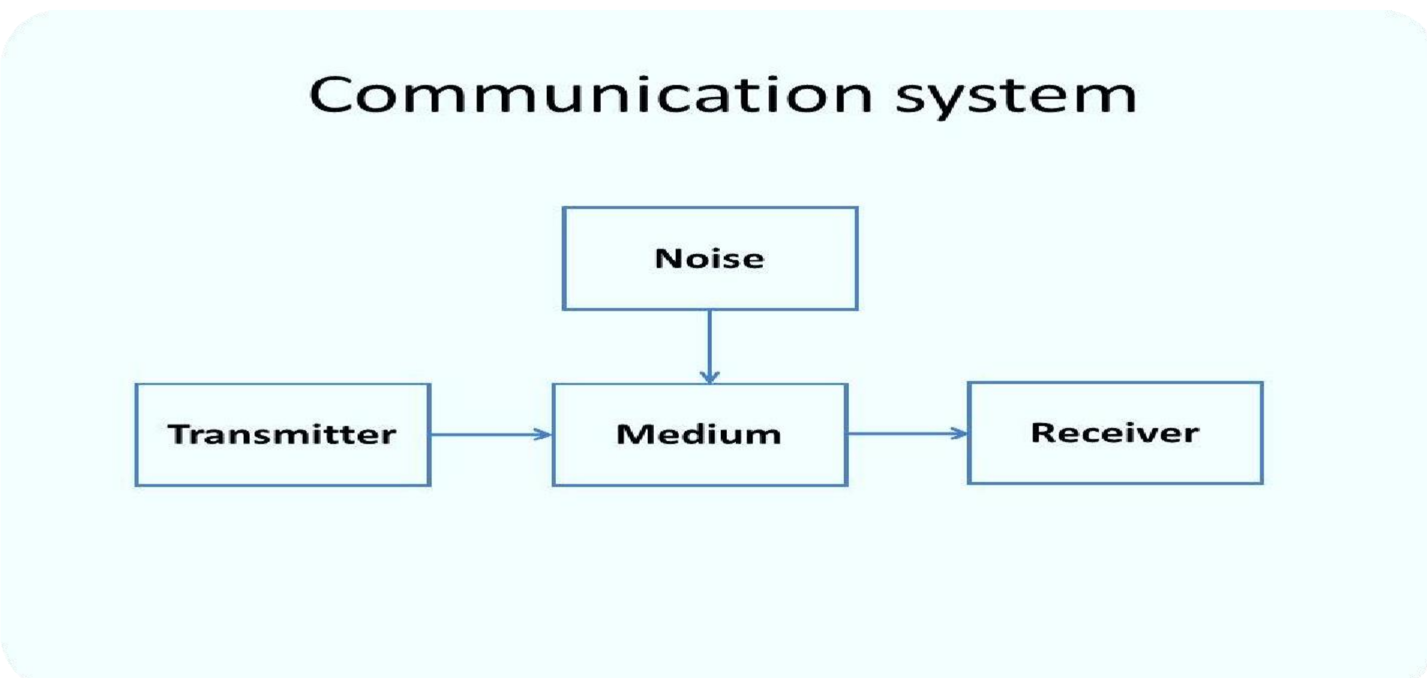
The purpose of the transmitter is to convert the message signal into a suitable form with the help of transducers. The signal may be in analogue or digital form.

2. Channel: -

the channel is the physical medium like wires or cables or it may be wireless that connects the Transmitter and the Receiver. Here it may get distorted due to channel imperfections and moreover noise (Unwanted signal) adds to the signal.

3. Receiver: -

The receiver reconstructs the corrupted version of the signal and delivers it to the user.



TWO MODES OF COMMUNICATION

1. point-to-point:-

In point-to- point mode, communication takes place over a link between a single transmitter and a receiver.

ex:-Telephony.

2. Broadcast:-

In this mode , there are large number of receivers corresponding to a single transmitter.

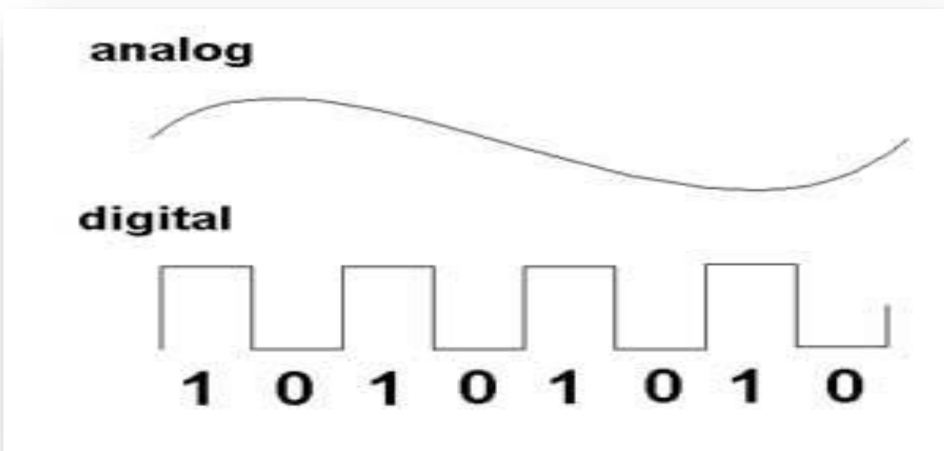
ex:- Radio and Television.

SIGNAL

Information converted in electrical form and suitable for transmission is called signal.

A signal can be analogue or digital.

Analogue signal is continuous variation of voltage or current ,whereas digital signals are those which can take only discreate stepwise values (0 and 1 values in Binary system).



BANDWIDTH OF SIGNALS

S. No	Description	From-To	Range
1.	Speech signals	300 Hz-3100 Hz	2800 Hz
2.	Music	20 Hz – 20KHz	20KHz
3.	Video Signals		4.2 MHz
4.	TV signal (Both voice and Picture)		6 MHz

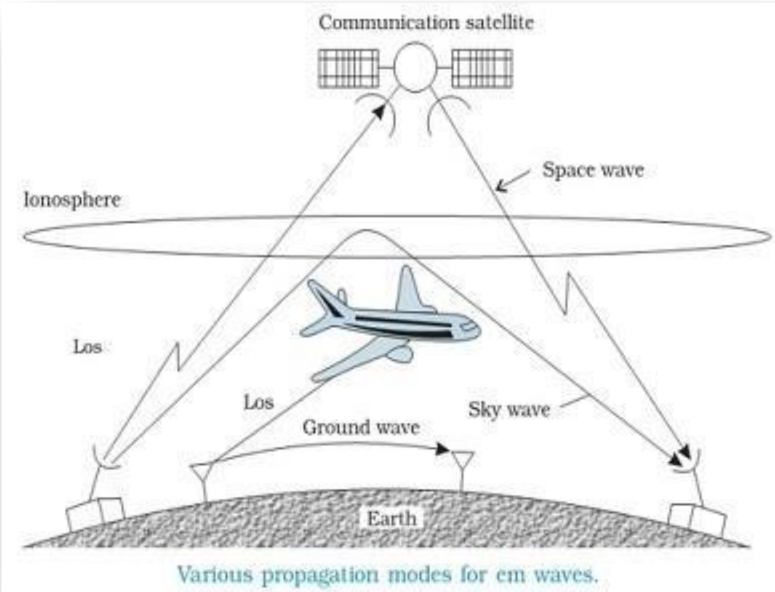
Note:- if the bandwidth is large enough we can accommodate more information without loosing the higher harmonics.

Coaxial cable is used as wire medium which offers a **band width of 750MHz**.

communication through **free space** using radio waves has a range from **a few hundreds of KHz to a few GHz.**

Optical fibers can offer a bandwidth **more than 100 GHz.**

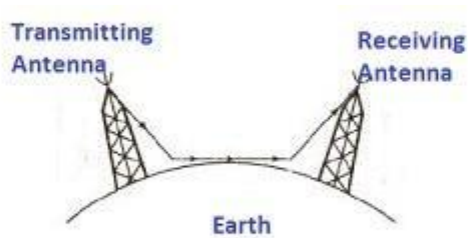
PROPAGATION OF ELECTROMAGNETIC WAVES



Various propagation modes for em waves.

1.GROUND WAVE: -

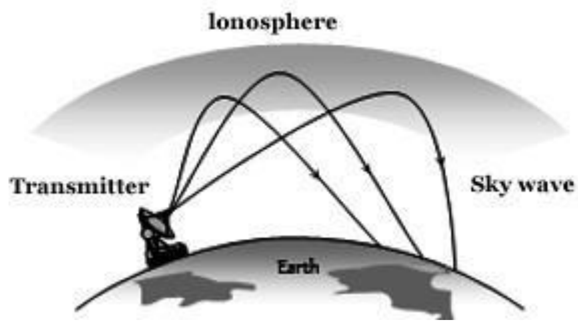
Electromagnetic waves at longer wavelengths (at lower frequencies) are propagated as ground waves with the help of large antennas ($\sim\lambda/4$). This mode of propagation is called surface wave propagation as the wave glide over the surface of the earth. The wave induces current in the ground over which it passes and it is attenuated as a result of absorption of energy by the earth. The frequency range of the signal that uses ground wave propagation is below30MHz.
Ex. AM broadcast.



2. SKY WAVE: -

Electromagnetic waves in the frequency range of 30 MHz to 40 MHz can be propagated for long distances by ionospheric reflection. Ionospheric layer acts as a reflector for frequencies up to 30MHz.The phenomenon of reflection of em waves by the ionosphere is similar to Total internal reflection of light.
Ex. Short wave broadcast services like BBC and Radio Amateurs (Marconi used short waves

for communication)



3. SPACE WAVE.

Space wave propagation is used for frequencies beyond 40MHz.
At these frequencies, the antennas are relatively smaller and can be placed at heights of many wavelengths above the ground.
A space wave travels in a straight line from transmitting antenna to the receiving antenna.
Space waves are used for line-of-sight (LOS) communication as well as for satellite communication.
Ex: - Television broadcast, microwave links and satellite communication use space waves.

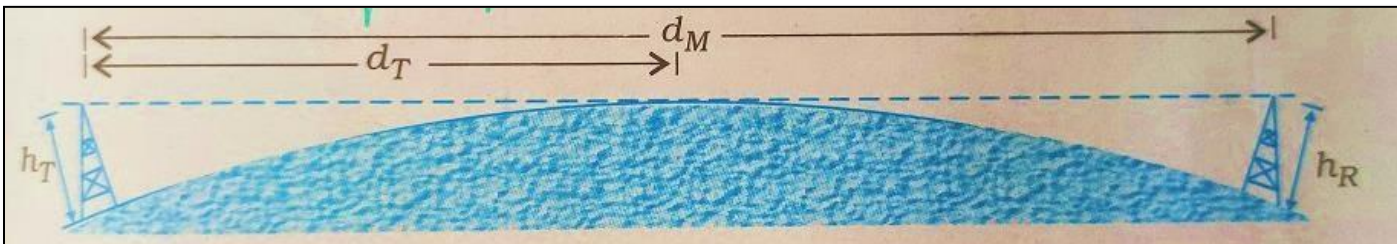


FIGURE 15.5 Line of sight communication by space waves.

Because of line-of-sight nature of propagation, direct waves get blocked by the curvature of the earth. To receive the signal beyond the horizon, the transmitting and receiving antennas must be high enough to intercept the line-of-sight waves.

Radio horizon of transmitting antenna $d_T=\sqrt{2Rh_T}$

The maximum line-of-sight distance between two antennas $d_M=\sqrt{2Rh_T}+\sqrt{2Rh_R}$

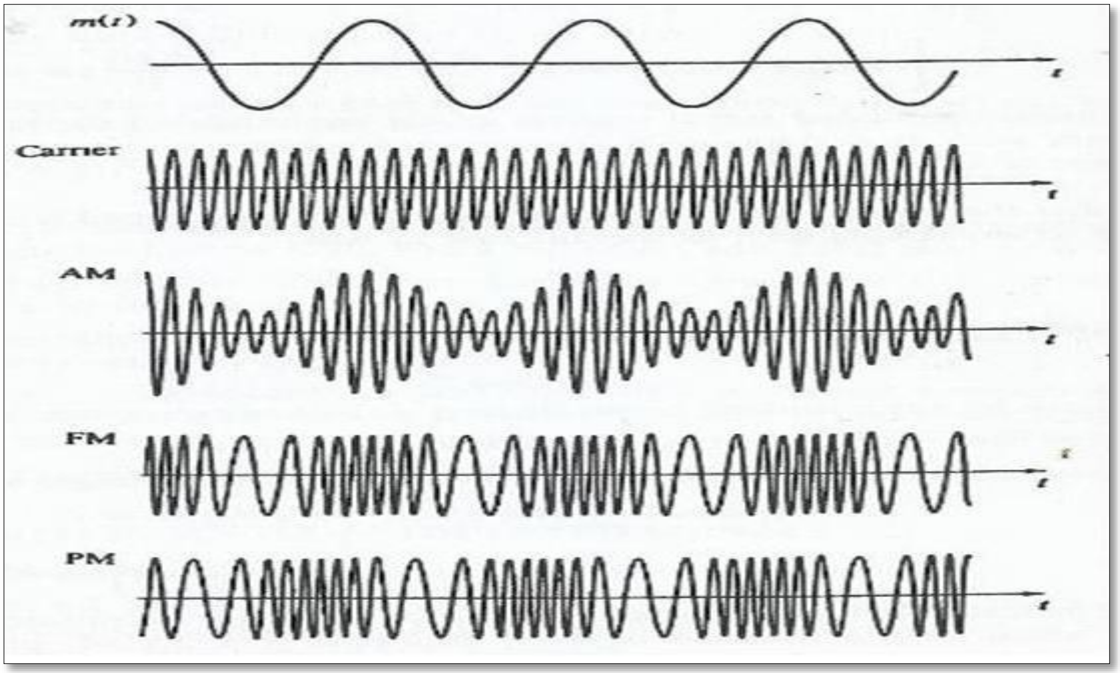
MODULATION AND ITS NECESSISTY.

Mixing of low frequency signal with high frequency carrier signal is called modulation.

a) To reduce the size of the antenna.
b) To increase the radiation power which is proportional to $(l/\lambda)^2$. So, power radiated is increases with decreasing λ or increasing frequency.

TYPES OF MODULATION

1.Amplitude modulation (Amplitude of carrier wave is modulated).
2. Frequency modulation (Frequency of carrier wave is modulated).
3. Phase modulation (phase of the carrier wave is modulated).



If A_m is the amplitude of modulated wave and A_C is the carrier wave, then $\mu = \frac{A_m}{A_C}$ is the

modulation index. μ is kept ≤ 1 to avoid distortion.
The maximum amplitude of AM wave is $(A_C + A_m)$ and minimum amplitude is $(A_C - A_m)$
Amplitude modulated signal contains frequencies $(\omega_c - \omega_m)$,ω_c and $(\omega_c + \omega_m)$

PRODUCTION AND DETECTION OF EM WAVES

AM waves can be produced by application of message signal and the carrier wave to a non-linear device, followed by a band pass filter.
AM detection is carried out using a rectifier and an envelope detector.

SHORT ANSWER QUESTIONS

1.what are the basic elements of communication systems?
2.what are transducers? give an example?
3.what is the frequency range of speech signals?
4. what is the frequency range of music?
5.what is bandwidth of a signal, give the bandwidth of TV signals?
6. What is sky wave propagation?
7. Why space wave propagation is used for are broadcasting TV signal?
8. Define modulation. Why is it necessary?
9. mention the basic modes of modulation.
10. What is modulation index? How to keep its value to avoid distortion.

FILLUP THE BLANKS

1. The process of increasing the amplitude of the signal using an electronic circuit is called______________________(Modulation/ Amplification).
2. The process of retrieval of information from carrier wave at the receiver is is termed as__________________(Modulation/ Demodulation)
3. For short distance communication like AM broadcast employs ____________________(Ground waves/sky waves).
4. Communication that employs sky waves which are reflected by______________ (troposphere/ionosphere), a layer of gas above the earth surface.
5. __________________ (sky waves/space waves) are used for line-of-sight communication as well as for satellite communication.
6. To radiate signals at wavelength λ, the antennas should have the size at least _________________(λ or λ/4).
7. Power radiated by the antenna can be increased by _________________ (increasing/decreasing) the frequency of the signal.
8. Mobile phones use___________(sky waves/ space waves) for communication.
9. In communication via internet, the computers are connected by

_______________(satellite/ optical fibers).

10. To propagate high frequency signal with frequency more than 40MHz, we need_________________(ionosphere/ satellite).

(Ans: - 1) Amplitude 2) Demodulation 3) Ground waves 4) ionosphere 5) space wave 6) $\lambda/4$ 7) increasing 8) space waves 9) optical fibers 10) satellite.

TRUE OR FALSE

1. The digital communication is far more advantageous than the analogue communication because large number of digital signals can be sent through a single channel only. (T/F)
2. Space waves travel directly from the transmitting antenna to the receiving antenna, whereas the sky wave propagation is by the reflection of ionosphere. (T/F)
3. All the technologies of telegram, Telephone, Radio and Tv were converged in a single device called mobile phone. (T/F)
4. The frequency of outgoing and incoming calls is different in mobile phone to avoid overlapping of signals. (T/F)
5. The word MODEM is the short form for modulator and demodulator (T/F)
6. Tv signals being of high frequency are reflected by the ionosphere back to the earth.(T/F)
7. Pilot asks the passengers in the flight to keep their mobiles in airplane mode, since the Mobile signals cause interference with airplane navigation (T/F)
8. A passing motorcycle causes disturbance with reception signal in the radio because the spark plug fitted in the engine produces electro-magnetic signals due to sparking. (T/F)
9. We get poor signal inside a metal cage like an elevator(lift) because, lift behaves like a faraday cage and blocks the electro-magnetic waves entering into it. (T/F)
10. Using a wired telephone during a thunderstorm is dangerous because it is connected by wires outside. A cell phone however is safe to use inside your home as it has no connection with outside wires. (T/F)

(Ans:-1(T), 2(T), 3(T), 4(T), 5(T), 6(F), 7(T),8(T),9(T),10(T))

MATCH THE FOLLOWING

1. Match the input transducers with their output transducer pair.

I	II
1. Microphone	a) LCD display
2. keyboard	b) speaker
3. camera	c) monitor
4. Force sensors(buttons)	d) Lights

(Ans: - 1-b, 2-c, 3-a, 4-d)

2.Match the signal with is propagating medium

I	II
1. Short Radio waves	a) Coaxial cable
2. Light signal (LASER)	b) sky
3. Electrical signal	c) Air molecules
4. Sound(shouting)	d) Optical fiber

(Ans: - 1-b, 2-d, 3-a, 4-c)

3. Match the following processes with their terminology

I	II
1) Any device that converts one form of energy into another	a) Attenuation
2) Unwanted signal	b) Bandwidth
3) The loss of strength of signal while propagating	c) Transducer
4) Frequency range over which an equipment operates	d) Noise

(Ans:-1-c, 2-d, 3-a, 4-b)

4.Match the communication waves with their utility

I	II
1.Short distance communication	a) space wave
2.communication beyond the horizon	b) ground wave
3. line of sight communication between antennas for sending high frequency waves	c) sky wave
4.Mobile communication	

(Ans:- 1-b, 2-c, 3-a, 4-a)

5)Match the modern communication technologies with their terminology

I	II
1.Telegraphy	a) Telephonic transmission of scanned printed material
2. Facsimile	b) transmission of textual messages using codes
3. Internet	c) wireless transfer of voice or data using radio waves
4.mobile	d) world wide network of computers for exchange of information

(Ans:- 1-b, 2-a, 3-d, 4-c)

MULTIPLE CHOICE QUESTIONS

1.Modualation is done in

a) Transmitter b) Radio receiver

c) Between transmitter and receiver d) None

2. which mode of communication is not employed for transmission of TV signals?

a) Ground wave propagation b) sky wave propagation

c) Space wave propagation d) None

3.Modulation is the process of superposing

a) Low frequency audio signal on frequency radio waves

b) Low frequency radio signal on low frequency audio waves

c) high frequency audio signal on low frequency radio waves

d) low frequency audio signal on low frequency radio waves

4)Audio signal cannot be transmitted because

a) the signal has more noise

b) signal cannot be amplified for long distance communication

c) the transmitting antenna length is very small to design

d) the transmitting antenna length is very large and impracticable

5) An antenna is a device that converts

a) Electromagnetic energy into radio frequency signal

b) Radio frequency signal into electromagnetic energy

c) guided electromagnetic waves into free space electromagnetic waves and vice-versa

d) none of these

6) which of the following frequencies will be suitable for communication using sky waves?

a) 10kHz b) 10MHz

c) 1GHz d) 1000GHz

7) Frequencies in the Ultra high frequency range (UHF) normally propagated by means of

a) Ground waves b) sky waves

c) surface waves d) space waves

8) Ionospheric reflection of sky waves is similar phenomenon like

a) Reflection of light b) transmission of light
c) Refraction of light d) total internal reflection of light

9) The fundamental radio antenna is a metal rod which has a length equal to
a) λ in free space at the frequency of operation
b) $\lambda/2$ in free space at the frequency of operation
c) $\lambda/4$ in free space at the frequency of operation
d) $3\lambda/4$ in free space at the frequency of operation

10) In an amplitude modulated wave for audio frequency of 500Hz, the carrier frequency will be
a) 50Hz b) 100Hz
c) 500Hz d) 50,000Hz

11) If the heights of transmitting and receiving antennas are each equal to h, the maximum line of sight distance between them is(R is the radius of earth)
a)$\sqrt{2Rh}$ b)$\sqrt{4Rh}$ c) $\sqrt{6Rh}$ d) $\sqrt{8Rh}$

12) In frequency modulated wave
a) frequency varies with time
b) amplitude varies with time
c) both frequency and amplitude vary with time
d) both frequency and amplitude are constant

13)Digital signals
i) do not provide a continuous set of values,
ii) represent values as discrete steps,
iii) can utilize binary system, and
iv) can utilize decimal as well as binary system
which of the above statements are true?
a) (i) and (ii) only b) (ii) and (iii) only
c) (i), (ii) and (iii) but not (iv) d) All of (i), (ii), (iii) and (iv)

14) A modulating signal $m(t) = 10\ cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal c(t) = 50 cos($2\pi \times 10^5 t$). Find the modulation index.
a) 0.2 b) 0.01
c) 0.5 d) 0.02

15) It is necessary to use satellite for long distance TV transmission because
a) TV signal has short wavelength
b) TV signal has long wavelength
c) TV signal has light signal

d) TV signals are not reflected by ionosphere

(Ans:- 1-a , 2-a, 3-a, 4-d, 5-c, 6-b, 7-d, 8-d, 9-c, 10-d, 11-a, 12-a, 13-c, 14-a, 15-d)

PROBLEMS (LEVEL-I)

1. A Tv tower has a height of 300m. what is the maximum distance up to which this tv Transmission can be received. (Ans:- 62Km)
2. A transmission antenna at the top of a tower has a height 32m and the height of the receiver antenna is 50m. what is the maximum distance between them for satisfactory communication in line -of-sight mode? Given radius of earth 6400km. (Ans: 45.5km)
3. A carrier wave of peak voltage 15V is used to transmit a message signal. Find the peak voltage of the modulating signal in order to have a modulation index of 60%? (Ans: 9V)
4. The maximum amplitude of an AM wave is found to be 15V while its minimum amplitude is found to be 3V. What is the modulation index? (Ans: 2/3)
5. A signal of 5KHz frequency is amplitude modulated on a carrier wave of frequency 2MHz. The frequencies of the resultant signal is/are (Ans: 2005KHz, 2000kHz, 1995KHz)
6. A telephonic communication service is working at a carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a band width of 5kHz? (Ans: 2x 10^5)

PROBLEMS (LEVEL-II)

1. What should be the height of transmitting antenna if the Tv telecast is to cover a radius of 128km? If the average population density around the tower is 1000/km^2, how much population is covered? (Radius of the earth R= 6.4x $10^6 m$. (Ans: 5.14x 10^7)

THE END

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